

Understanding adaptive capacity through a resilience thinking lens: How deregulation
has changed the adaptive capacity of the New Zealand apple industry.

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Abstract

The New Zealand apple industry is subject to environmental, economic, social, institutional, political and climate change disturbances. System disturbances require an adaptive capacity to respond to potential opportunities and minimise potential risks. A variety of factors will influence adaptive capacity as it is socially constructed, context dependent, and dependent on multiple factors, including political and institutional frameworks, and capital resources.

The apple industry experienced significant changes during and after deregulation in the 1990's. These changes affected the industry structure, social and institutional frameworks, and the performance and profitability of the industry. These factors play a large role in establishing the context which determine how apple growers operate and their adaptive capacity to external disturbance.

This thesis assesses how deregulation has affected the adaptive capacity of the apple industry with respect to climate change. The study area is Hawke's Bay, the largest apple growing region in New Zealand. The resilience thinking framework is used to frame the problem and characterise adaptive capacity. A case-study approach was taken using semi-structured interviews to investigate the changes caused by deregulation and how it has affected adaptive capacity for industry participants.

Results suggest deregulation has increased the adaptive capacity of the apple industry. Following deregulation, apple growers have access to more knowledge, economic capital, and more technology to manage environmental conditions and climate fluctuations. Deregulation stimulated corporatisation which has created a competitive and innovative culture. Several large companies operate across the supply chain and participate in research and development, growing, packing, marketing, and exporting. These companies produce niche fruit varieties, target specialised markets, and invest in technological development. In general, the apple industry operates with more diversity, this includes diversity in the ownership and operating structures of grower and processing entities, apple cultivar diversity, and export market diversity.

This study also suggests several caveats which might limit adaptive capacity, including reduced social capital for apple growers, a reduction in the number of independent growers, and the expansion of apple production onto marginal soil types and settings.

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Chapter One: Introduction

Climate change is occurring and is expected to affect the Hawke's Bay with warmer temperatures and more frequent extreme weather events (Mullan, Sood, Stuart, & Carey-Smith, 2018). Climate change will create both opportunities and risks to apple production in the Hawke's Bay. Warmer temperatures and increased CO₂ concentration are expected to increase yields, fruit size, and vegetative biomass (Clothier, Hall, & Green, 2012). However, extreme weather, extreme hot temperatures, and variable precipitation will increase disease and pest pressure, affect water supply, reduce winter chilling, and increase the risk of fruit damage due to extreme weather events (Clothier et al., 2012). Climate change is a concern to the apple industry in Hawke's Bay as it accounts for approximately 60% of national apple production (Stats NZ, 2018b), and contributes significantly to the region's economy, including approximately 4% of total regional employment (Infometrics, 2018).

Adaptations are required to adjust orchard systems in anticipation of, or in reaction to, potential risks, impacts, and opportunities (Engle, 2011). Growers make adaptations on a daily basis in response to climate stimuli, such as rainfall and temperature, and also a range of economic, political, technological, and social stimuli (Darnhofer, Fairweather, & Moller, 2010). Growers, like all agricultural producers, operate within a complex social-ecological system (Darnhofer et al., 2010). Orchards are managed by the grower, who is shaped by wider social and cultural norms. Orchards are agri-businesses which operate within an industry structure shaped by political, institutional, and economic frameworks. Orchards are also agro-ecosystems, comprised of a variety of hydrological, physiological, carbon, nitrogen, and phosphorus cycles. A complex combination of factors influence orchards which require on-going adaptations to maintain system function and resilience.

Adaptive capacity is the ability for a system or individual to adjust, cope, or minimise the potential impacts of system disturbance or stress (Klein, 2014). Enhancing adaptive capacity will improve the ability for the apple industry to manage the range of climate change effects, and plan and respond to future risks and opportunities.

Adaptive capacity is determined by a number of social factors including, human capital, social capital, economic capital, institutions, and political processes (Pelling, 2011). Adaptive capacity is dependent on the social and political context of the system, and the way people can organise and mobilize resources (W. N. Adger et al., 2011). Literature suggests the social dynamics of a social-ecological system are influenced by political processes which shape the industry structure, organisational arrangements, and the context in which individuals operate (Pelling, 2011). This highlights the need to understand the social dynamics when assessing adaptive capacity.

The apple industry experienced major changes following full export market deregulation in 2001. Deregulation dismantled the New Zealand Apples and Pears Marketing Board (NZAPMB), the single desk marketing board that controlled the acquisition and sale of all exports between 1948 and 2001 (McKenna & Campbell, 1999). Following deregulation, the apple industry experienced significant change, this included increased productivity, increased competition, and a significant industry reorganisation (Dobbs & Rowling, 2006). This changed the context of the apple industry and the environment in which growers produce apples (Dobbs & Rowling, 2006). To date, research has not examined the effect of deregulation on the adaptive capacity of the New Zealand apple industry. This is important to understand as apple industry participants will require adaptive capacity to manage system disturbance associated with climate change.

1.1. Aim and Scope

The primary aim of this thesis is to assess the adaptive capacity of the apple industry regarding the risks and opportunities posed by climate change. The question I propose is: How has the adaptive capacity of the apple industry changed following deregulation?

Hawke's Bay is the setting for this project because it is the largest apple growing region in New Zealand and is expected to experience the effects of climate change (Mullan et al., 2018). Apple industry participants were interviewed in this study to determine the factors that characterise their adaptive capacity.

I apply resilience thinking framework to understand the complex system change that took place following deregulation. The resilience thinking framework emerged from ecological literature but was later adapted by Gunderson & Holling (2002), and others (Brian Walker & Salt, 2006), to include complex social-ecological systems. In this framework, the development of a system is characterized by change, uncertainty, and persistence. Resilience thinking offers a framework to consider the thresholds that maintain system states, and system transformation to alternative states. The resilience thinking framework includes the following key principles:

- the adaptive cycle;
- system hierarchies;
- system thresholds and alternative states; and
- adaptability and transformability.

This thesis provides a case study on the Hawke's Bay apple industry to apply the resilience thinking framework and assess how the key changes following deregulation. This is to understand what structural, economic, cultural, environmental, and social changes occurred to understand if these will affect the ability of the Hawke's Bay apple industry to respond to shocks and disturbance.

1.2. Significance of study

This study uses a resilience thinking framework as a method to frame the question and characterise adaptive capacity. The resilience thinking framework has been used to understand farm system sustainability (Darnhofer et al., 2010), and analyse political change in the Australian dairy industry (Sinclair, Curtis, Mendham, & Mitchell, 2014). Prior to this study, the resilience thinking framework has not been applied to the New Zealand apple industry nor has it been used to assess adaptive capacity. The resilience thinking framework provides a novel and holistic approach to assess the wide-ranging effects of deregulation on adaptive capacity. This is important because adaptive capacity is influenced by the social dynamics that shape the social context. This study attempts to fill a gap in the literature which assesses adaptive capacity through a resilience lens.

1.3. Outline of thesis

Chapter Two presents the theory behind adaptation and adaptive capacity. I explore the key concepts, the factors affecting adaptive capacity, and the approaches to understanding adaptive capacity. I argue adaptive capacity requires a resilience thinking approach to emphasise social-ecological system interactions, feedbacks, and processes that occur in complex and dynamic systems. I then discuss the four components of the resilience thinking framework and the adaptive capacity indicators that I use to complement the resilience thinking framework. The indicators include social capital, diversity and redundancy, feedbacks, and economic capital which help me characterise adaptive capacity.

Chapter Three provides the context of the apple industry in the Hawke's Bay. The chapter describes the physical setting, the environmental and climate conditions, and the social, political, and institutional context. Finally, Chapter Three describes the historic structure of the apple industry, and the global political, economic, and social dynamics that preceded deregulation.

Chapter Four is the results chapter and continues the adaptive cycle discussion post deregulation. Chapter Four is framed around the four components of the resilience thinking framework and discusses the factors that characterise adaptive capacity.

Chapter Five provides the discussion and conclusion of the research. It also presents caveats regarding the findings and outlines the strengths and weaknesses of the resilience thinking framework.

The research design is presented in the appendix. This outlines the case study and qualitative approach used to collect data from apple industry participants.

Chapter Two: Adaptation as a resilience thinking concept

2.1. Adaptation

Adaptation is a process of change that occurs in response or in anticipation to system disturbance (Pelling, 2011). Individuals will always be required to adjust social-ecological systems to external pressures. Climate change is an example of a system disturbance that will require a response to the observed or expected impacts, risks, and opportunities. The purpose of adaptation is to minimise the negative impacts of change and to take advantage of any new opportunities created (Wreford, Moran, & Adger, 2010).

Climate change adaptation aims to either decrease the exposure, decrease the sensitivity, or increase the resilience of the system (Wreford et al., 2010). Altering the exposure affects the magnitude of change the system is likely to experience. Adaptations that decrease the exposure may involve hazard preparedness, or impact mitigation (N. W. Adger, Arnell, & Tompkins, 2005). Reducing the sensitivity of a system reduces the degree to which the system will be affected. For example, planting climate resilient crops or increasing water storage infrastructure decreases the sensitivity of the system (N. W. Adger et al., 2005). Increasing the resilience of a system increases the ability for the system to respond to change (Ofori, Stow, Baumgartner, & Beaumont, 2017). Increasing the resilience may increase resource availability, enhance knowledge development, increase the diversity of the system, or increase the coping capacity (N. W. Adger et al., 2005). Brooks et al., (2005) relate the level of exposure and sensitivity to the vulnerability of a system. Without adaptations, climate change will be disruptive and costly to agricultural producers, and detrimental to agricultural based economies.

2.1.1. Characteristics of adaptation

Skinner & Smit (2002) developed an adaptation typology for agriculture producers that involves four categories, technical adaptations, governmental programs and insurance, farm production practices, and farm financial management (Smit & Skinner, 2002). Adaptations can be further categorized based on who is adapting, the operation in focus, and the scale of the system. Adaptations can be implemented across a range of ecological, social, economic, or political systems, and across local, regional, or national spatial scales (N. W. Adger et al., 2005). Furthermore, adaptations can be proactive in anticipation of future stress or disturbance, or reactive in response to observed changes or events (Pelling & High, 2005).

The Ministry of Primary Industries, (2012) categorized adaptations as tactical, strategic, or transformational. Tactical adaptations involve small, short term changes, such as management adjustments in response to weather events. Strategic adaptations are longer term adaptations that involve moderate planning and investment. Strategic adaptation may involve new management

techniques or new technologies. Transformational adaptations are large scale, long term adaptations, such as land use change.

Hadarits et al. (2017) categorized adaptations as incremental, transitional, or transformational. Incremental adaptations are on-going adaptive responses to maintain the integrity or function of the system (Hadarits et al., 2017). Often these are will be tactical adaptations in response to change. Transformational adaptations are system transformations that create fundamentally new biophysical, economic, or social processes (Hadarits et al., 2017). Transitional adaptations are intermediary adaptations that prepare the system for transformational change. This classification emphasises the effects of adaptations on the system.

Hadarits et al. (2017) demonstrated the ability for adaptations to occur across scales. Adaptations can initiate change that create feedback effects for multiple individuals operating at different scales. For example, Hadarits et al. (2017), in a case study on Canadian Irrigation Districts, found adaptations made by district authorities constrained farmers' adaptive capacity. In an attempt to increase water efficiencies, open canals were converted to pipelines to reduce aquatic weed and reduce evaporation during drought periods. In this example, a high level adaptation had a negative effect on flood management for farmers in the region. This caused farmers to implement a series of adaptations to mitigate the new risks that were created. One transformational adaptation at a regional scale set the boundaries for incremental adaptations at a local scale. Hadarits et al (2017) noted "incremental and transformational adaptations can set the bounds for, or constrain, one another, as actions that make the system well adapted to one change can reduce flexibility to deal with other changes. This highlights the role of scale in both vulnerability and adaptive capacity. Disturbance and adaptive capacity can occur at different scales and affect the focal system (at an orchard level or industry level).

Adaptations that lead to unintended, detrimental outcomes are known as maladaptations. These might fail to reduce vulnerabilities, fail to increase adaptive capacity, or result in costs and consequences (Rickards & Howden, 2012). Incremental adaptations that fail to address long-term climate risks can cause the system to move down a vulnerable and undesirable pathway. This is because they can create a false sense of security or inadequately respond to long-term risks and hazards (Rickards & Howden, 2012).

2.1.2 Adaptive Capacity

Adaptive capacity is the ability to mobilize and apply resources in anticipation or in response to perceived or current stress (W. N. Adger et al., 2011). The adaptive capacity of a system or individual is determined and maintained by social processes including institutional, political, and economic factors (Pelling, 2011). Adaptive capacity is socially constructed and dependent on the context of the system (Engle, 2011). This means adaptive capacity varies from region to region, person to person, and depends on historic processes (Smit & Wandel, 2006). Gunderson & Holling (2002) discuss adaptive capacity as a dynamic system property that changes throughout the development of a system. Adaptive capacity is a key concept in resilience thinking literature because it is the ability for a system to maintain its basic function and purpose throughout periods of change and adversity.

2.2. Factors affecting Adaptation and Adaptive Capacity

A number of factors affect adaptive capacity and the ability for individuals, systems, and organisations to respond to change. These factors can act as limits or barriers depending on the focal system (Dang, Li, Nuberg, & Bruwer, 2019). Barriers present obstacles that make it harder to adapt, however these can be overcome through thinking, managing, planning, and regulating (Moser, Ekstrom, & Kasperson, 2010). Limits present absolute thresholds that cannot be overcome with the existing human, financial, or physical resources (Moser et al., 2010).

Dang et al. (2019) identified five major groups that affect agricultural producers' ability to adapt to change: demographic and socio-economic factors; resources, services, and technologies; institutions and political factors; social and cultural factors; and cognitive and psychological factors. These factors have different effects on adaptive capacity depending on the region and context of the study (Arbuckle, Morton, & Hobbs, 2015; Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Keskitalo et al., 2011). For example, studies on adaptive capacity in developing countries often emphasise the role of socio-economic and demographic factors such as land ownership, access to financial support and credit, (Bryan, Deressa, Gbetibouo, & Ringler, 2009), age, education, gender, and wealth (Deressa et al., 2009) as the most important factors affecting adaptive capacity. Socio-economic and demographic factors pose numerous limits and barriers for in all countries, however it is important to keep the context of the study in mind to determine the most influential factors.

New Zealand's apple industry is ranked number one in the world by the World Apple Review, based on a range of indices including production efficiency, industry infrastructure, and other financial/market factors (Bagrie, Williams, & Smith, 2015). New Zealand growers are fortunate to have relatively high income and access to resources, services, and technology (Morris, 2006).

Therefore, the socio-economic and demographic factors in New Zealand do not pose the same limits and barriers as they do for developing countries.

Niles et al. (2015) highlighted adaptation on New Zealand farms is highly dependent on the farm system because each farm system operates in a different political and institutional structure, with different social and cultural characteristics (Darnhofer et al., 2010). These have the ability to shape different cognitive and psychological processes such as perceptions and behaviours towards climate change adaptation which affect adaptive capacity. The following sections review the most relevant factors to affect adaptive capacity in the New Zealand context, based on literature reviews from developed countries and factors identified from Niles et al. (2015). This includes political and institutional factors, social and cultural factors, and psychological and cognitive factor.

2.2.1 Political and institutional factors

Political and institutional processes are important for developing policy frameworks that determine regulations on how agricultural producers operate and what they can do (W. N. Adger et al., 2011; Keskitalo & Kulyasova, 2009; Smit & Wandel, 2006). Research suggests political and institutional factors contribute to the performance of the industry, social capital, management of resources, and technological development (Carolan, 2006; Dow, Haywood, Kettle, & Lackstrom, 2013; Isoard, 2011; Wolf, 2011). Furthermore, political frameworks are important for effective goal setting, governance structures, and generating adaptation action (Isoard, 2011).

Political and institutional factors also create barriers to adaptation and adaptive capacity. Walker et al. (2015) found climate change policies often lag behind necessary levels of action and tend to be reactive rather than proactive. In a case study on England's transport sector, Walker et al. (2015) found central government had not created the necessary frameworks to integrate climate change information into policy. Local authorities found it difficult to implement adaptations due to limited cross-department coordination and national policy to facilitate effective planning and decision making. Moser & Eskom (2014) examined the political barriers to climate change adaptation in California and found a similar set of problems. They suggested a lack of integrated federal government policy frameworks create inadequate response at a state level. Moser & Eskom (2014) believe a combination of low levels of funding, limited levels of data collection, low levels of planning, and low levels of external and internal institutional coordination are creating barriers to adaptive capacity in California (Ekstrom & Moser, 2014).

Research highlights a disconnection between willingness to adapt and actual adaptation implementation at a political level (Benjamin Walker, Adger, & Russel, 2015). Integrating knowledge into political and institutional planning, developing cross-scale and cross-departmental coordination, and focusing on long term issues, were the main institutional barriers for developed nations (Ekstrom & Moser, 2014; Benjamin Walker et al., 2015).

Boston & Lawrence (2018) argue New Zealand's current funding, planning and regulatory frameworks are inadequate to respond to climate change. They argue the numerous policy frameworks that consider climate change adaptation and mitigation are poorly aligned with no consistency (Boston & Lawrence, 2018). This includes the RMA (1991), Soil & Conservation Act (1941), Civil Defence Emergency Management Act (2002), and Building Act (2004). These acts have different goals and timeframes regarding climate change. Boston & Lawrence (2018) argue a lack of consistency reduces the ability for local authorities to make proactive adaptations. Similar to other developed nations, they also suggest New Zealand's political frameworks focus too much on post-event recovery, such as the Adverse Events Fund and EQC Earthquake Commissioner. These financial funds tend to be ad hoc and inconsistent according to Boston & Lawrence (2018), which can create barriers to adaptation and adaptive capacity.

2.2.2. Social and Cultural Factors

Social and cultural factors contribute to an individuals' social networks, knowledge networks, and beliefs, all key factors which affect adaptive capacity (Seville, 2016). Carolan (2006), found farmers develop their social networks based on social and cultural factors that form their shared values and beliefs. Social networks play a large role in farmers' knowledge sources and management practices (Carolan, 2006). This suggests network associations can create barriers to adaptive capacity, depending on the common beliefs and culture of the social network. Arbuckle et al. (2015), found farmers who trusted agricultural-interest groups, such as the farm-press and other agribusiness companies, were less likely to believe in human-induced climate change. These agricultural-interest groups were known opponents of climate change policy (Arbuckle et al., 2015). While farmers who expressed trust in environmental-interest groups, such as federal agencies, state agencies, conservation organisations, and environmental organisations, were more likely to believe in human induced climate change.

2.2.3. Cognitive and psychological factors

Several studies have identified the role of cognitive and psychological factors, such as perceptions, and learning abilities for influencing agency, behaviour, and adaptive capacity (Arbuckle et al., 2015; Niles & Mueller, 2016). These are shaped by the numerous social, political, institutional and cultural factors that determine how an individual will interpret information and reason with information (W. N. Adger et al., 2009; Wolf, 2011).

The relationship between climate change perceptions, future concerns, and actual adaptive action has been researched extensively (Arbuckle et al., 2015; Niles, Lubell, & Brown, 2015; Niles & Mueller, 2016). Results from Niles et al. (2016), Arbuckle et al. (2013), and Mase et al, (2017) found there is positive correlation between belief in climate change and concern for future climate change

impacts. Arbuckle et al. (2013), and Mase et al. (2017), went further to suggest farmers that were concerned about the impacts and risks of climate change were more supportive of adaptation actions and climate change policy. Li et al. (2018), disagreed with this, finding there was no relationship between belief in climate change (the perception of hazards) and actual adaptation behaviour. They found the main factors that determined adaptation were farmers stock of human capital, social capital, financial capital, and the farm characteristics.

Climate knowledge is either passed down from older generations, obtained from personal experiences, acquired from weather data, or anticipated using future models or scenarios (W. N. Adger et al., 2009). Niles et al. (2016), found the majority of New Zealand farmers' climate change knowledge did not align with climate change data. This indicates agricultural producers have a range of climate change knowledge sources and interpret these sources differently. Niles et al. (2016), also found certain adaptations, such as irrigation infrastructure, can influence the perceptions of farmers. Farmers who used irrigation were more likely to believe annual rainfall trends were increasing compared to non-irrigating farmers, despite no significant changes to regional rainfall since the 1980's. Niles et al. (2016), suggest technology, and the ability for it to control environment variables, can affect perceptions. Many factors determine how growers source knowledge, interpret knowledge, and develop climate change perceptions. These factors have the ability to affect adaptive capacity in the apple industry (Niles & Mueller, 2016).

A complex combination of political, social, cultural, and cognitive factors can influence adaptive capacity. These factors have all been found to be salient in the New Zealand context (Engle, 2011; Niles et al., 2015). Many of these factors are interrelated and influence the adaptor simultaneously, which highlights the difficulty identifying and determining key factors that affect adaptive capacity. Research tends to focus on single factors or groups of factors that affect adaptive capacity (Dang et al., 2019). A holistic system thinking approach that considers the relationship between key factors might provide a more robust method to understand and characterise adaptive capacity (Engle, 2011).

2.3 Approaches in understanding adaptive capacity

Adaptive capacity is generally discussed in terms of vulnerability and resilience research (Engle, 2011). Vulnerability generally takes an actor-centric focus and discusses an individual's exposure or sensitivity to a range of hazards (Engle, 2011). Adaptive capacity through a vulnerability lens represents the ability for an individual to reduce exposure to stress or a hazards. However, in the pursuit to determine how an actor will respond to hazards, researchers often overlook the dynamics and context of the system that characterise adaptive capacity (Engle, 2011).

Adaptive capacity through a resilience lens takes a slightly different perspective (Engle, 2011). Adaptive capacity is the ability for individuals to manage and determine their resilience (Engle, 2011). Adaptive capacity through a resilience lens emphasises adaptability and transformability to transition the system to an alternative system state in the face of hazards or stress such as climate change.

Resilience theory has evolved over time and has a range of definitions and interpretations. The more traditional concept of engineered resilience, focuses on system stability around an equilibrium state (Gunderson & Holling, 2002). Examples of engineered resilience include physical infrastructure that provide quantifiable resilience, e.g. a flood levee capable of withstanding a 1 in 100 year flood. Holling (1973) first developed the concept of ecological resilience and defined it as the ability for the system to absorb changes while maintaining system function. This definition focuses on how far a system can be disturbed and still return to an equilibrium state (Miller et al., 2010). The concept of ecological resilience evolved to consider social-ecological systems (Gunderson & Holling, 2002). The IPCC (2008) definition of resilience is, “the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change” (IPCC, 2008). Others recognise social-ecological resilience not only as the capacity for a system to maintain same structure and function, but also the ability to transform and renew itself (Folke et al., 2010; Nelson, Adger, & Brown, 2007; Pelling, 2011; Brian Walker & Salt, 2006). This interpretation of social-ecological resilience emphasises adaptive capacity, self-organisation, learning, and transformation (Nelson et al., 2007).

Some policies that apply fixed outcomes, such as maximum sustainable yield in fisheries or engineered structures, do not actually increase long-term social-ecological resilience. Rather, these mechanisms aim to maintain stability which do not necessarily increase resilience in adaptive systems (Brian Walker & Salt, 2006). It can create situations where systems are locked into a specific range of conditions and variables and are unable to respond to new threats. This can cause systems to move down a pathway towards an undesirable state. This is known as the transitional pathway which is shaped by path dependencies and lock-in effects, i.e. the past decisions that affect the pathway of change (Wilson, 2014). Wilson (2014) discusses neoliberalism as a lock-in effect which has shaped the transitional path of society. Neoliberalism has shaped the current agricultural policy in New Zealand, and has had a range of effects on economic, social, and environmental processes. These factors can contribute to the resilience of the system and influence its adaptive capacity (Engle, 2011).

Agricultural systems are inherently dynamic social-ecological systems that experience multiple types of stress and disturbance (Darnhofer et al., 2010). External stress puts pressure on the coping mechanism and internal controls that maintain system function. Understanding adaptive capacity through a resilience lens acknowledges system thresholds but suggests systems can adapt and transform to more resilient alternative states. Climate change will likely affect system variables such as water availability or extreme hot weather that will push orchards away from desirable states. The more adaptive capacity in the system, the more flexible and adaptable the system will be to transition or transform back into a desirable state, depending on what is deemed more 'desirable'.

2.4. The Resilience Thinking Framework

The resilience thinking framework provides a framework to assess adaptive capacity through a resilience lens. The framework takes a systems thinking approach to understand complex system changes and interactions (Brian Walker & Salt, 2006). The resilience thinking framework has roots in Gunderson and Holling's (2002) concept, 'panarchy', which is based on the adaptive cycle model, and the hierarchies' concept. The adaptive cycle characterises system change, and hierarchies refers to the interactions between and across other interconnected social and ecological systems. The resilience thinking framework also includes *thresholds and alternative states*, and *adaptability and transformability*. Resilience thinking has been used to understand sustainable agriculture (Darnhofer, 2010), and the transformation of Australia's dairy industry (Sinclair et al., 2014). The following sections will examine the different components of the resilience thinking framework and review the literature that has applied the resilience thinking framework.

2.4.1 The Adaptive Cycle

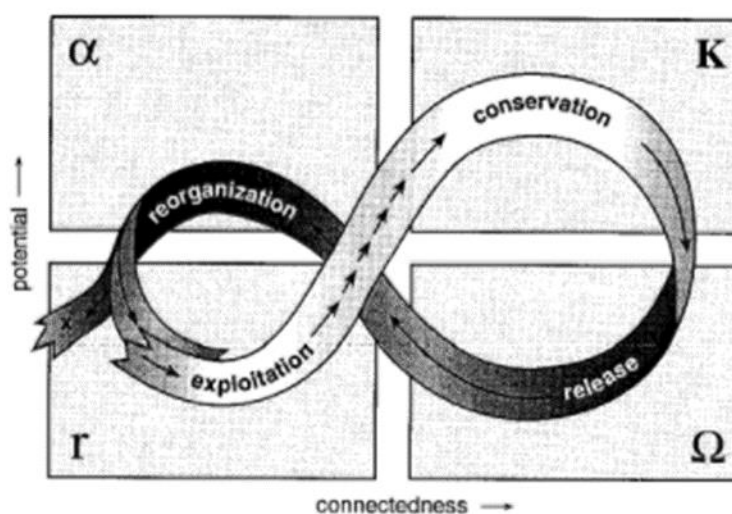


Figure 2. 2 The Adaptive Cycle (Holling, 2001).

The adaptive cycle is comprised of four phases: exploitation, conservation, release, and reorganisation, as indicated in Figure 2.1. The different phases are characterised by three main properties: resilience, potential, and connectedness (Figure 2.1.). Potential and connectedness are represented on the y and x axis. Resilience is a third dimension (although not presented on Figure 2.1.), and like connectedness and potential, changes throughout the phases of the adaptive cycle.

- Potential: This can be viewed as the stock or accumulation of capital (social, human or financial) and resources. It also reflects the potential available for change (Holling, 2001).
- Connectedness: the degree of connectedness between the internal controlling variables or elements of the system. This is the degree of flexibility or rigidity of the system (Gunderson & Holling, 2002).
- Resilience: This is the resilience of the system which is the ability for the system to respond to shocks, indicated by adaptive capacity.

2.4.1.1 The exploitation phase

The exploitation phase is often a long period of growth and accumulation. During this phase potential and connectedness slowly increase as the system exploits the environment and develops the internal controls to maintain system stability. In an ecosystem, this will involve colonisation, and biomass and nutrient accumulation. In a social system, capital and knowledge accumulate, and social networks strengthen, fuelling investment and growth.

Connectedness between interrelated entities increases as expansion continues (Gunderson & Holling, 2002). During the exploitation phase resilience is high. The system is stable and the future will appear to be predictable and resilient to external forces. System components develop strong and efficient relationships that control external variability (Kolka, 2013).

2.4.1.2 The conservation phase

Potential and connectedness are high during this phase. New entrants find it difficult to enter the market due to fewer opportunities in a highly organised and stable system. Organisations may struggle to develop growth so will remove redundancies to refine operations and increase efficiencies (Brian Walker & Salt, 2006).

During the late stages of the conservation phase resilience is low. Systems become over-connected and rigid, making them vulnerable to external disturbance (Brian Walker & Salt, 2006). Diversity is squeezed out as management continues to refine system processes. Gunderson & Holling (2002), note “systems become accidents waiting to happen.”

2.4.1.3 The release phase

The release phase is triggered by a disturbance such as a climate event, policy change, or other system shock. The system collapses rapidly releasing potential that was once tied up in the system. Social networks and relationships erode, capital investment fail, or environmental resources deplete (Gunderson & Holling, 2002). Gunderson & Holling (2002) suggest connectedness will initially remain high as internal controls still remain intact, however as the internal controls weaken, the system structure threatens to break down. At this point the future of the system is uncertain (Brian Walker & Salt, 2006).

2.4.1.4. The reorganisation phase

The system will reorganise and restructure during the reorganisation phase. Potential is higher during this phase because systems can adapt their processes and respond to the disturbance (Gunderson & Holling, 2002). There is room for novelty and innovation, creating opportunities for early innovators and entrepreneurs. Connectedness remains low because systems are young and yet to establish internal connections and controls. Systems that survive the reorganisation phase will enter the exploitation phase again and restart the adaptive cycle. Resources will begin to accumulate, and connectedness will increase.

2.4.1.5 Applying the adaptive cycle

The adaptive cycle is a key component of the resilience thinking framework that describes the patterns and processes of change in a system (Sinclair et al., 2014). It is a generalised model to describe both living and non-living systems. Sinclair et al. (2014) found the Australian Dairy industry followed a similar adaptive cycle, which helped to understand deregulation and its effects on the industry structure, working practices, and supply chain processes.

The case study found deregulation, while having the desired impact on industry growth and productivity, degraded environmental systems and broke down social capital. In response to environmental degradation, producers increased their knowledge, sought advice, upgraded farm infrastructure, and reduced herd sizes to ease system pressures. Numerous feedback effects affected the social capital, human capital, environmental capital, and financial capital of the Australian dairy industry. Further reorganisation caused several social and ecological systems to cross system thresholds and move to alternative system states. Sinclair et al. (2014) found the adaptive cycle useful for understanding system change, however limited, due to its generalised framework that cannot accurately account for all system processes.

2.4.2. Hierarchies

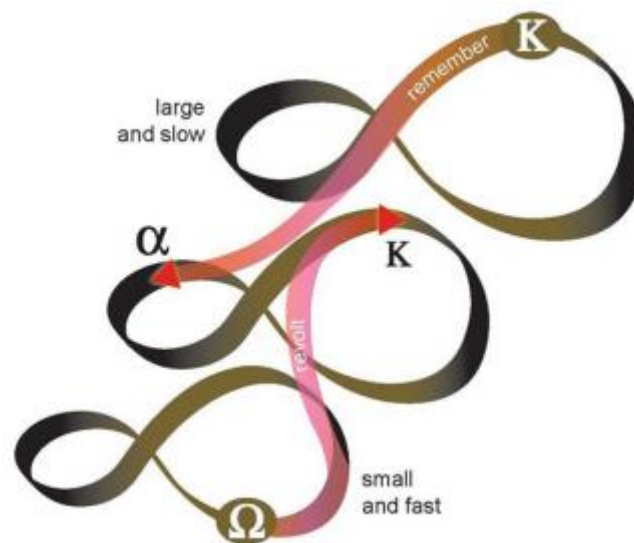


Figure 2. 3 Adaptive cycles arranged in hierarchies which represent the scale at which the system operates (The Resilience Alliance, 2019b).

Hierarchies, the second component of the resilience thinking framework, refers to “the manner in which elements of a complex adaptive system nest in one another in a hierarchy” (Gunderson & Holling, 2002). Complex social-ecological systems (SES) are comprised of multiple system elements, or subsystems, each operating at a specific scale, and each in their own adaptive cycle. As subsystems proceed through their adaptive cycle they interact with other subsystems, both at a higher and lower scales, and both across time and space (Gunderson & Holling, 2002). These interactions contribute to the behaviour of the social-ecological system, and the externalities and feedback effects that cause systems to move to more or less desirable states (Brian Walker & Salt, 2006). For example, Sinclair et al. (2014), demonstrate the role of hierarchies for determining management practices and causing social change in the dairy industry. Political change was a high level process that caused change to cascade across multiple scales, including structural change, and social network reconfiguration. Individuals were either forced to leave the industry, or transform their farm management to stay competitive in the market. Pressure was applied on the ecological systems, animal health suffered, environmental resources degraded, and nutrient inputs increased (Sinclair et al., 2014). Numerous interconnected subsystems interacted across scale to influence the overall function and dynamics of the social-ecological system (Sinclair et al., 2014).

2.4.3. Non-linearity, alternative regimes, and thresholds

Thresholds are the boundaries systems operates within (Brian Walker & Salt, 2006). Social ecological systems are capable of crossing thresholds and existing in alternative states. Some of these are less desirable, such as eutrophication, salt water intrusion, crop failure, or coral bleaching. Apple orchards operate within a number of environmental thresholds including, nutrient, water, climate,

disease and pest systems etc. These thresholds determine the stable states that control apple production. There are also numerous social systems with social thresholds that control the stable states such as markets, management, social networks, and cultural systems (Brian Walker & Salt, 2006). Crossing a threshold does not necessarily cause a catastrophic collapse but it can cause a transition to an alternative state. For example, a farmer converting some of their productive land into a forest regime will not breakdown the farm enterprise and cause a collapse. However, if enough patches of farm are converted, it may cause farm costs to exceed farm revenues, and cause the farm enterprise to collapse. In this case, a system transformation would be required to change the function or purpose of the farm system. Passing a threshold into a new system state changes the resilience of the system, depending on what is deemed desirable and how it affects the adaptive capacity (Engle, 2011).

2.4.4. Adaptability and Transformability

Adaptability and transformability is the ability for actors to use adaptive capacity and adjust system processes (Sinclair et al., 2014). Adaptability and transformability accounts for human agency and the ability to influence social-ecological system resilience (Sinclair et al., 2014). Adaptability and transformability might involve incremental change, to move a system away from a threshold, or transformation change, to intentionally cross a threshold into a new state. As previously discussed, not all adaptations can enhance resilience. Some adaptations move the system to a less desirable state. The adaptive cycle theory highlights the adaptive nature of social-ecological systems which requires adaptability and transformability to ensure system function. For example, adaptability and transformability will be required to ensure apple production while external changes such as climate change, market change, and political-economic change affect the resilience of the system.

2.5. Adaptive capacity indicators

Adaptive capacity indicators will be complementary to the resilience thinking framework to help characterise adaptive capacity. Social capital, diversity and redundancy, environmental capital, economic capital, and feedbacks will be discussed as key indicators to adaptive capacity (Seville, 2016). These elements will develop an appropriate adaptive capacity assessment to understand how individuals learn to live with change, nurture adaptive capacity, develop the knowledge to increase learning capabilities, and create opportunities to self-organize towards social-ecological resilience (The Resilience Alliance, 2019a).

2.5.1. Social Capital

Social capital is an important aspect of adaptive capacity because it facilitates organisation, learning, collective action, and social support (W. N. Adger, 2003). Social capital is a widely studied phenomenon, researched by sociologists, economists, and political scientists to describe how social,

knowledge, and political networks are developed (Nahapiet & Ghoshal, 1998; Wilson, 2012). Many of the concepts behind social capital are derived from the work of Bourdieu (1984), Coleman (1990) and Putnam (1993). Bourdieu (1987) defined social capital as capital mobilized through social networks and relations. Putnam (1993) built on this work in his book, *Making Democracy Work*, which investigated the institutional performance, governance and economics among Italy's twenty governmental regions. He analysed the variations between the regions and found cultural forces were a major cause for many political and social outcomes (Pierce, Lovrich, & Budd, 2016). This led him to identify the role of trust among individuals and institutions that enable collective action and engagement (Pierce et al., 2016). Putnam defined social capital as "features of organization, such as trust, norms and networks that can improve the efficiency of society by facilitating coordinated actions" (Putnam, Leonardi, Nanetti, Putnam, & Nanetti, 1994).

Literature suggests social capital is necessary to support climate change adaptation. This is because it determines access and transfer of knowledge (Burt, 2004), social support (W. N. Adger, 2003; Dowd et al., 2014), institutional trust (Jones & Clark, 2014), improved governance (Bodin & Crona, 2009), attitudes towards policy (Jones & Clark, 2014), and effective management of natural resource usage, allocation, and governance (Bodin & Crona, 2009). Jones & Clark (2014) showed institutional trust improves perceptions and attitudes on policy and enhances confidence in climate change information. The climate denial movement indicates how trust can develop uncertainty, undermine climate science, and negatively impact adaptation (McCright & Dunlap, 2010).

Social networks consist of the social ties, which form the pattern of the network, and the type of social interactions, which form the content of the network (Bodin & Crona, 2009). The pattern of the network consists of bonding, bridging, and linking networks (Bodin & Crona, 2009). Bonding networks are the connections within a tight group of individuals (Bodin & Crona, 2009; Wilson, 2012). Research suggests bonding ties are important for knowledge transfer and generation, and consensus building due to regular interactions that occur between the individuals (Bodin & Crona, 2009; Curry & Kirwan, 2014; Reagans & McEvily, 2003).

Bridging networks are the weak ties that connect bonding networks (Bodin & Crona, 2009). These are important for learning new information, knowledge development, and innovation. Burt (1992) suggests those that bridge networks have access to broader knowledge and have higher chance of developing innovative and novel ideas. He argued those who are limited to bonding networks are more likely to develop homogenous behaviours, knowledge, and opinions (Burt, 2004).

Dowd et al. (2014) studied the effect of networks on climate change adaptation. The study compared the social networks between incremental and transformational adaptors. Results found

transformational adaptors had stronger bridging networks than incremental adaptors. Dowd et al (2014), suggests transformational adaptors require new information and tend to look beyond their geographic or bonding networks to seek diverse information.

Groenewald & Bulte (2012) investigated the role of trust in climate change adaptation. Farmers who had low levels of institutional trust were less likely to diversify their farm operation, and generally stuck to traditional farming activities. Whereas farmers who expressed high levels of institutional trust were more likely to invest in alternative strategies to diversify production. Furthermore, farmers who had high levels of social trust within their bonding network, were more likely to follow the social norm and maintain traditional forms of agriculture (Groenewald & Bulte, 2013). These studies indicate trust is influential in behaviours, management approaches, and adaptive capacity.

2.5.2. Diversity and Redundancy

Systems with greater diversity are generally more resilient than those with less diversity (Simonsen et al., 2015). Diversity can refer to activities, people, institutions, and organisations. Diversity allows systems to function when certain system components fail. For example, a farmer with several different crops has greater resilience because the failure of one crop will not impact the entire production system. Redundancy is the presence of multiple components that serve the same purpose or function. This is valuable if the components react differently to change or disturbance (Simonsen et al., 2015). For example, two different farmers managing the same type of crop provides redundancy. Furthermore, organisations that provide the same function however have different structures, cultures, and management, will likely react differently to different economic or political shocks. Resilient systems should value and conserve diversity and redundancy. Optimizing economic efficiency often comes at a cost to redundancy and diversity (Simonsen et al., 2015).

2.5.3. Feedbacks

Managing feedbacks are important in social-ecological systems to counteract system disturbance or maintain system resilience. Adaptations are implemented to manage feedback effects. Generally, adaptations dampen the external stimulus to reduce the effects of the change. For example, overhead spraying is used in some horticultural systems when temperatures exceed 30°C for latent cooling and reduce the effects of extreme hot temperatures. Resilience systems have strong dampening feedbacks that maintain desirable system states (Simonsen et al., 2015). It is important to avoid actions that prevent dampening feedbacks. Simonsen et al. (2015), suggests it is important to monitor slow variables that may cause thresholds to cross. These are the variables that do not require urgent action but can act as positive feedback effects that reinforce or enhance system change. Monitoring information to understand external stimuli is important to apply the appropriate mechanisms that reduce the effects of change.

2.5.4. Economic capital

Economic capital influences an individual or organisations access to assets and resources. This can influence infrastructure, material assets, level of education, access to credit, and institutional support (Whitney et al., 2017). Several studies highlight the importance of economic capital for building adaptive capacity (Li et al., 2018).

2.6. Conclusion

Adaptive capacity will be required to respond to the risks and opportunities caused by climate change and other external changes. Adaptive capacity is shaped by many social processes such as political and institutional, social and cultural, and cognitive and psychological factors. These factors shape the way individuals develop planning framework, mobilize resources, develop social networks, share knowledge, and perceive risk.

Literature highlights the need to view adaptive capacity through a resilience thinking lens to accept system complexity, instability, and change as an inherent component of social-ecological systems. (Engle, 2011). Responding to change is required to maintain system resilience to avoid crossing system thresholds to less desirable system states.

The resilience thinking framework provides a method to understand system transitions, system interactions, system thresholds, and adaptations and transformations. This is a holistic approach to help understand the Hawkes's Bay apple industry context and characterise adaptive capacity.

This study draws upon four key resilience thinking indicators identified in literature that will help characterise adaptive capacity. The indicators include social capital, diversity and redundancy, feedbacks and economic capital.

Chapter Three: The context of apple production in the Hawke's Bay

3.0. Introduction

Assessing adaptive capacity requires an understanding of the system and its context. This chapter investigates the apple industry in Hawke's Bay and the key processes that make up its social-ecological system. I first examine the physical setting, climate, and environment, followed by examination if the political, economic and institutional systems that shape the industry structure. Subsequently, I review the formation of the New Zealand Apples and Pears Marketing Board (NZAPMB) and the history of the Hawke's Bay apple industry leading to deregulation.

3.1. Environmental and Physical Setting

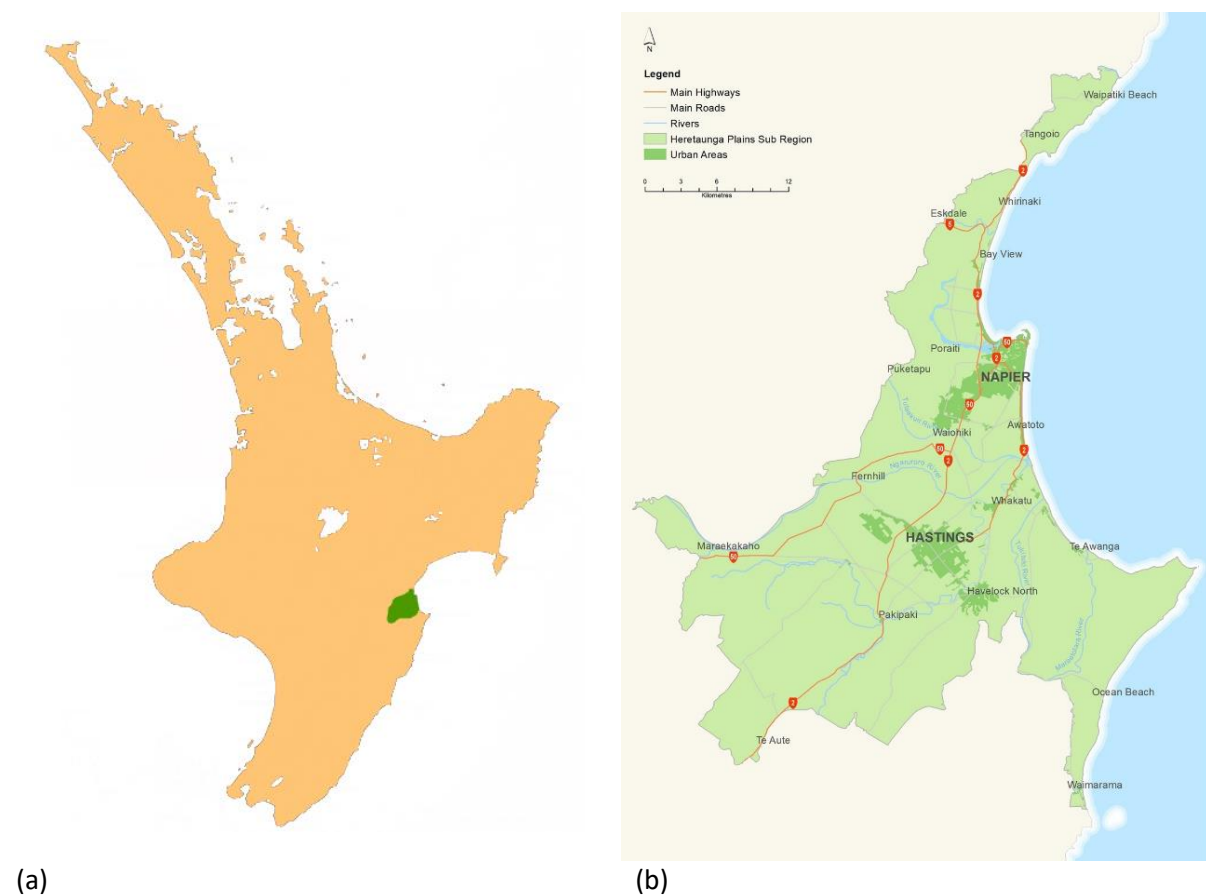


Figure 3. 1 (a) Heretaunga Plains at national scale, and (b) Heretaunga Plains at regional scale (Hawke's Bay Regional Council, 2017; Heretaunga Plains, 2019)

Hawke's Bay is located on the east coast of the North Island. The region has a diverse topography including mountain ranges to the north and west, plains and hill country, and a diverse coastline. The region consists of four districts, Wairoa District, Hastings District, Central Hawkes Bay District, and Napier City (Hawkes Bay Regional Council, 2019). Hastings District is the largest district in land area

and population (pwc, 2013). Agriculture is the second largest sector in Hawke's Bay's, contributing 12.1% of total GDP, behind manufacturing (13%) (Infometrics, 2018).

Pastoral farming, horticulture (pipfruit, stone fruit, and vegetable), and viticulture are the main agricultural industries. Pipfruit growing is the largest employer in Hawke's Bay, accounting for 4% of total jobs in the Hawke's Bay (Infometrics, 2018). Infometrics (2018) noted horticulture & fruit growing has a significant comparative advantage in the Hawke's Bay, due its natural endowment, location, and specialised skills.

Around 60% of New Zealand's total apple plantings are grown in the Hawkes Bay, with most of this grown on the Heretaunga Plains (Mannering, 2017). The Heretaunga Plains is a 300 km² alluvial plain, located at the southern end of Hawke's Bay (Dravid & Brown, 1997). The Heretaunga Plains were formed over the last 250,000 years by erosion and sediment deposition from the Tutaekuri, Ngaruroro, and Tukituki rivers (Dravid & Brown, 1997). The Heretaunga Plains are a combination of sandy loam, loamy fine sand, silt loam, and stone soils (Wilton, 2008). Generally, these are well-draining and fertile soils, however susceptible to wind erosion (Wilton, 2008).

Hawkes Bay has a maritime-temperate climate, with relatively high sunshine hours (approximately 2150 hours on the Heretaunga Plains) (Chappell, 2013). The Heretaunga Plains have variable rainfall, of approximately 800 mm of rainfall per year (Chappell, 2013). The low rainfall increases dependence on irrigation.

High density horticulture on the Heretaunga Plains is reliant on groundwater sources for irrigation. Available groundwater is a major natural resource which supplies approximately 85% of the plains and adjacent areas with water (Dravid & Brown, 1997). Climate change may affect groundwater recharge which will create a risk to apple growing on the Heretaunga Plains (Clothier et al., 2012).

The combination of fertile alluvial soils, temperate climate with high sunshine hours, and groundwater resources makes the Heretaunga Plains favourable for apple production and gives the apple industry a competitive advantage.

3.2. Climate Change

Over the last century New Zealand's average temperature has increased by 0.9 °C (Mullan et al., 2018). New Zealand's average temperature is expected to rise by 0.7 - 1.0 °C by 2040, and 0.7 - 3.0°C by 2090 (relative to average temperatures from 1986 - 2005) (Mullan et al., 2018). Hawke's Bay average temperatures are predicted to increase by 0.7 - 1.3 °C by 2040 and 0.7 - 3.1 °C by 2090 which is slightly higher than the national average (Mullan et al., 2018).

The number of extreme high temperature days and extreme low temperature days are predicted to change (Mullan et al., 2018). High temperature extremes days (days exceeding 25°C), are expected to increase from 27.5 days (current average), to 36.3 - 41.6 days by 2040. Low temperature extremes days (days or nights dropping below 0°C), are expected to decrease, from 16.0 days, to 10.1 - 7.8 days by 2040 (Mullan et al., 2018).

Rainfall is another important variable predicted to change. Hawke's Bay annual rainfall is expected to decrease by 1-2% by 2040. The winter and spring seasons are expected to have reduction in rainfall, and the summer and autumn seasons are expected to increase (Mullan et al., 2018). By 2090, annual rainfall is expected to decrease by 2-5% annually, with decreases up to 17% in winter, and increases up to 16% in summer (Mullan et al., 2018).

Annual precipitation changes are not particular large, however the large seasonal precipitation change and extreme weather events that will be associated with it are concerning (Mullan et al., 2018). Overall, the frequency of dry days is expected to increase which will increase drought risk. Rainfall events are predicted to decrease in duration but increase in magnitude for the Hawke's Bay (Mullan et al., 2018). The increased risk of drought and extreme rainfall is a threat to Hawke's Bay apple production. Impacts will vary depending on the adaptive capacity of the institutions, organisations, and individuals.

3.5. Institutional frameworks

3.5.1. Resource Management Act (1991)

New Zealand agricultural producers operate within the Resource Management Act (1991), a multi-level governance framework which determines the use and allocation of natural and physical resources (Ministry for the Environment, 2018). Figure 3.1 outlines the hierarchical approach to natural resource management in New Zealand and the designated national, regional, and district level roles.

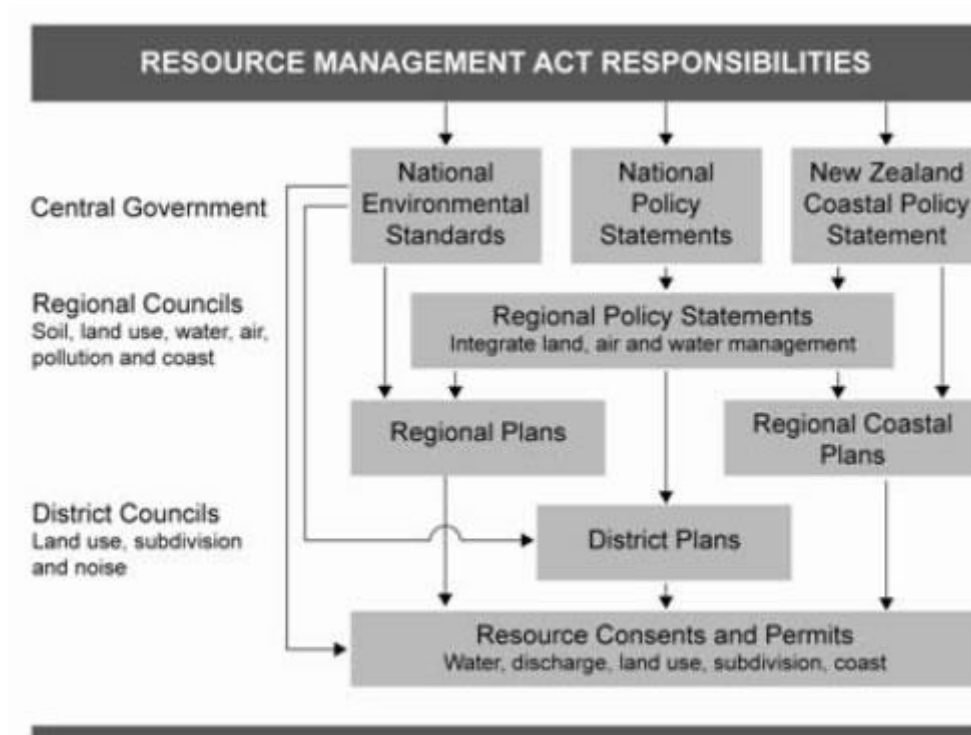


Figure 3. 2 Resource Management Act (Ministry for the Environment, 2018)

National policy statements, and national environmental standards aim to create consistent frameworks on topics such as climate change. Under the RMA (1991) local governments are required to incorporate climate change into existing frameworks, plans, and decision-making procedures. For example a climate change perspective is required in flood management, water resource management, building regulations, and transport (Ministry for the Environment, 2018). However, as Boston & Lawrence (2018) argues the frameworks appear to have inconsistencies across regional and local authorities.

3.5.2. Central, Regional and Territorial Authorities

Central government is split into different agencies to manage policies, standards, and regulations. The Ministry for Primary Industries regulate primary industry trade, exports, food safety, and biosecurity. The Ministry for the Environment regulate air, climate change, fresh water, marine, land, waste, energy, and biodiversity standards. Ministry for the Environment provide climate change impact assessments to identify risks and opportunities for councils to incorporate into regional and city planning (Ministry for the Environment, 2018). Both agencies work to achieve central government objectives, and work with regional and local authorities to determine regional policies and achieve the standards outlined in the national policy statements, and national environmental standards. Hawkes's Bay regional council has developed a Long-Term Plan framework to fulfil regional planning guidelines (Weaver, 2017).

3.5.3. Industry groups

New Zealand Apples and Pears is an industry group that represents the pipfruit industry. They operate within the political frameworks to support growers' technical, economic, marketing and policy information (New Zealand Apples and Pears).

3.4. Political-economic background

Global events, economics, and politics have shaped agricultural policy in New Zealand. Following WW2, there was a strong global commitment to create a stable agriculture regime and stimulate agricultural production (Almås & Campbell, 2012). New Zealand operated a highly protected, export orientated, agricultural industry (Hunt, Rosin, Campbell, & Fairweather, 2013). New Zealand was able to export the majority of its food production to Europe, particularly the UK.

Food security was a main concern for global agricultural policy post WW2 due to food procurement ideologies that developed as a result of WW1, WW2, and the post WW2 food crisis (Hunt et al., 2013). Agricultural policy focused on direct government intervention, state-owned enterprises, controlled supply chains, agricultural subsidies, and state investment into capital and R&D programmes (Almås & Campbell, 2012). This was known as the 'productivist' era (1945-1980's). Productivist policies focused on farm optimisation and economic efficiency, which lead to intensification, specialisation and concentration (Hunt et al., 2013). More was considered better, so farmers, governments and scientists focused resources on increasing output. As a result food production dramatically increased during this time.

Defects in productivist policies began to show through oversupply, caused by subsidising regimes, and intensive agriculture, which degraded natural resources and environmental amenities (Almås & Campbell, 2012). It caused many developed nations to rethink agricultural policy. One option for agricultural policy was to follow the neoliberal pathway, which involved deregulation and privatisation of agricultural sectors, abolishing producer subsidies, and liberalising food trade by creating free markets (Almås & Campbell, 2012). The other pathway, multi-functionality, promoted diverse income sources, organic farming, farm diversification, and environmental and cultural management. This response was the European alternative to neoliberalism, which was viewed by farmers, academics, and policy-makers as a more environmentally and socially sustainable (Almås & Campbell, 2012).

Following the 1984 elections of a Labour Government, New Zealand embarked down a neoliberal pathway which involved widespread economic reform (Hunt et al., 2013). Agricultural liberalisation and the benefits of reducing subsidies and tariff protections, were discussed extensively at the GATT Uruguay round (1986-1993)(Hunt et al., 2013). New Zealand was an advocate for agricultural

liberalisation after the neoliberal reforms. Other western countries were more reluctant to lose productivist policies of quota systems, price setting, and subsidy intervention, which aimed to protect their domestic producers (Hunt et al., 2013). New Zealand primary industries went through significant changes after neoliberal policies were adopted. Campbell, Lawrence & Smith (2006) summarised these as the following:

- Agricultural subsidies were removed
- Markets were liberalised and tariffs on imports were removed
- Cheap credit to undertake land development was removed
- Tax reforms implemented for agricultural producers
- Agricultural extension services were privatised
- Agricultural producer boards were dismantled and corporatized
- Strong support of GATT and WTO negotiations to liberalise world trade.

(Campbell, Lawrence, & Smith, 2006)

Advocates for neoliberalism thought it would provide an effective solution to world food supply through market driven incentives and world market integration. It was thought neoliberalism would enable cheap food to be produced and flow into developing countries (Almås & Campbell, 2012). However, neoliberalism did not provide the solution to global food systems as hoped. An estimated 100 million people moved from food secure to food insecure following the global food crisis in 2008. During the crisis, rich countries responded with 'land grabs', to secure their own food supply. Concerns were raised regarding the effectiveness of the neoliberal model and its resilience to respond to shocks. Climate change is expected to increase the pressure on food supply in many locations across the world and may cause global shocks to the system. New Zealand is highly connected with the global food market so will be affected by any changes to the global environment (Hunt et al., 2013).

3.5. The adaptive cycle

This section reviews the New Zealand apple industry transition through the adaptive cycle following the formation of the New Zealand Apple and Pear Marketing Board (NZAPMB) in 1948. This marks a system reorganisation and the beginning of the first exploitation phase which I suggest the continued until 1995 when the industry entered the conservation phase (1995-2001). A series of shocks followed by deregulation in 2001 is seen as the point at which the industry entered the release phase of the adaptive cycle.

3.5.1 Exploitation Phase (r): 1948 -1995

The Apple and Pear Marketing Board (NZAPMB) was established in 1948 (Morris, 2006). Following a period of reorganisation throughout the 1950's, the industry settled into a long period of growth,

characteristic of the exploitation phase (McKenna & Campbell, 1999). This was a period of single desk marketing, government intervention, and subsidies (until 1980), common under a productivist agricultural policy regime (McKenna & Campbell, 1999).

The industry expanded continually in both pipfruit growers and area of apples planted from 1949 - 1995, however growth accelerated from 1985 to 1995 as medium density rootstocks and new variety innovations (Jazz and the Pacific Series) increased productivity, and economic attractiveness (Morris, 2006). Production volumes increased 91%, and apple export volumes increased 106% (Bagrie et al., 2015). The industry was focused on increasing production volumes. The NZAPMB were bound by obligations to accept all apples that met export standards and export them under NZAPMB's marketing branch ENZA (Dobbs & Rowling, 2006). This encouraged growers to exploit the industry structure and focus heavily on production.

Many growers entered the industry through the 1980's and early 1990's due to the prosperous opportunities (Participant 3, 2018; Participant 11, 2018). The number of pipfruit growers expanded from 770 in 1985 to 1600 growers in 1995, and the area planted more than doubled, from 7,226 ha to 15,916 ha, much of this in the Hawke's Bay (Bagrie et al., 2015; Morris, 2006). Interviewees entered the industry through family connections or family-owned orchards, cadetships, transitioning land use, or purchasing land during this time (Participant 3, 2018).

All growers were part of a cooperative, which limited competition during this time, and encouraged social interactions with neighbours and fellow growers. ENZA held grower meetings and field days that were open to everyone. These were large scale meetings (up to 300-400 growers) and were efficient ways for networking and industry-wide learning (Participant 8, 2018).

This period of growth is characteristic of the exploitation phase and the industry was able to take advantage of the opportunities while buoyed by high apple prices (McKenna & Campbell, 1999). Potential and connectedness increased steadily as capital and knowledge accumulated, and networks developed. Local fruit processing factories, cool stores, and transportation networks increased as investment intensified (McKenna & Campbell, 1999). Knowledge development and innovation increased significantly, including New Zealand specific varieties, and medium density rootstocks (Bagrie et al., 2015; McKenna & Campbell, 1999; Morris, 2006). Connectedness grew within the industry as social networks developed among local producers and foreign export markets.

5.1.2. Conservation Phase (K): Mid 1990's – 2001

The conservation phase is characterised with high connectedness and potential. Skills and resources are high, and connections are well established between system components. Organisations have the internal controls to maintain stability, and are resilience to a specific range of conditions (Gunderson

& Holling, 2002). However, at the later stages of the conversation phase systems become too rigid, over-connected, and unable to respond to new shocks or surprises (Gunderson & Holling, 2002). At this point they are vulnerable to new shocks and surprises.

During this period, the apple industry was performing successfully and was ranked the most competitive apple producer in the world by the World Apple Review (1995) (Morris, 2006). The success was attributed to the structure of the NZAPMB which had been stable over an extended period of time (Dobbs & Rowling, 2006). According to theory, as a system converges towards a stable state, it loses the flexibility required to respond to new conditions or unexpected shocks (Brian Walker & Salt, 2006).

This was demonstrated by a series of declining years that followed peak performance in 1995. Firstly, global apple production had increased alongside New Zealand's production. This eventually led to an oversupply of apples in the global market, and a drop in the price of apples, which reduced returns to growers (Bagrie et al., 2015). Secondly, competition in key European markets had increased which reduced New Zealand's market share and further decreased the demand for New Zealand apples (Bagrie et al., 2015). Thirdly, the development of the technology "smart-fresh" enabled the shelf life of apples to improve. This enabled producers in the northern hemisphere to preserve their fruit until the off-season and then continue their supply to local markets. This resulted in a decrease in demand for New Zealand apples (Bagrie et al., 2015). Lastly, the 1990's were recognized as a time when consumer preferences began to change to greener, healthier food standards (McKenna & Campbell, 1999). This coincided with the shift towards large supermarket chains becoming the main suppliers in developed countries (Dobbs & Rowling, 2006). Initiatives such as EurepGAP, GlobalGAP, and other retailer groups such as the Fresh Produce Consortium, set benchmarks for food quality and product standards (McKenna & Campbell, 1999). The combination of consumer demands, large supermarket leveraging power, and a rise in food quality and product standards, increased the pressure on the apple industry for high quality products.

The NZAPMB responded to rising consumer standards and supermarket entry requirements, by introducing the Integrated Fruit Production (IFP) program in 1996, which reduced chemical residue on fruit (McKenna & Campbell, 1999). Growers were required to adapt to IFP and by 2001, 100% of exported fruit was produced under IFP (Wiltshire, 2003). The NZAPMB industry structure contributed to the fast adoption of the IFP. ENZA's monopoly enabled widespread implementation across the industry, without conflicting interests from multiple different entities (Wiltshire, 2003). High connectedness and potential enabled IFP to be adopted across the board. Growers were

offered a financial incentive, and ENZA was able to reduce risk through specific mitigation and risk reduction measures (Wiltshire, 2003).

Despite IFP, and the effective rollout, the industry was still unable to adapt to the changing market dynamics (Dobbs & Rowling, 2006). The international market was saturated, profit margins had narrowed and the industry lagged behind the global consumer demands, indicative of the conservation phase. During this time, the industry became vulnerable to surprise and unexpected shocks. A significant hail storm in 1997, and drought to Hawkes Bay in the 1998, almost caused a complete collapse of the industry (Dobbs & Rowling, 2006).

A combination of factors led the apple industry to deregulate. The Apple and Pear Marketing Amendment Act (1993) was passed to initiate deregulation. However, it was not until 1998 when the industry was near collapse did the government require NZAPMB to proceed to full deregulation (Gary, 2003). Despite the opposition, NZAPMB was converted into the company ENZA Limited in 1999, and by 2001, export controls were removed, enabling private exporters to enter the market.

3.6 Conclusion

Understanding adaptive capacity of the Hawkes's Bay apple industry requires an understanding of the local, regional, and global context. These factors shape the physical, environmental, economic, political and institutional factors that affect industry participants.

Overall, Hawke's Bay is an ideal location to grow apples with competitive advantages over other regions in New Zealand. The Heretaunga Plains have high quality fertile soils, a temperate climate with warm and dry summers, and groundwater resources. However, Hawke's Bay is vulnerable to the effects of climate change which are increase the number of extreme hot days and extreme weather events.

Leading up to deregulation, the apple industry was shaped by a number of global and national political-economic factors. A combination of neoliberal policies and globalisation, global overproduction in the apple market, and falling demand for New Zealand apple production lead to full deregulation of the industry in 2001. The following chapter will discuss the results of this study and answer the key research question: How has deregulation affected the adaptive capacity of the apple industry.

Chapter Four: Results

The results reveal the structural changes that occurred following deregulation have increased the capacity for the apple industry and its participants to adapt to change, including the risks and opportunities posed by climate change. Several factors lead to this conclusion including access to knowledge, increased diversity and redundancy, increased economic capital, and increased adoption of technology to manage environmental conditions and climate fluctuations.

4.1 The Adaptive Cycle:

This section examines the adaptive cycle of the apple industry following deregulation. Qualitative and quantitative data were used to observe industry changes as the industry proceeded through the release, reorganisation, and exploitation phases following deregulation. The changes that occurred in the industry represent changes in potential, connectedness, and resilience. These properties are used to help characterise adaptive capacity (Gunderson & Holling, 2002).

4.1.1 Release Phase (Ω): Deregulation 2001

Adaptive cycle theory suggests, suggest social-ecological systems move into the release phase in an instance (Gunderson & Holling, 2002). Structural connections and regulatory processes break down, and resources once bound up in the system are lost, releasing connectedness and potential in the form of environmental, social, and economic capital (Gunderson & Holling, 2002).

Successive seasons of declining export volumes and poor returns led the export market to full deregulation on the 1st October 2001 (Bagrie et al., 2015). Deregulation ended ENZA's monopoly and broke down the structure of the industry. Participants commented on the tough times following deregulation, relying on off-farm income for financial support (Morris, 2006; Participant 6, 2018) Dobbs & Dowling (2006) found deregulation negatively affected the performance of 93% of participant's businesses.

From 1995-2005, pipfruit plantings declined on average 3.6% per year, while pipfruit production declined on average 0.3% per year (Morris, 2006). Deregulation was successful in increasing the productivity of the industry as secondary growing regions such as Canterbury, Otago-Southland, Northland, and Auckland were no longer able to compete with the primary growing regions. It was no longer profitable for these regions to compete with the primary regions such as Hawke's Bay and Nelson-Tasman. The more favourable growing conditions and competitive advantage in Hawkes Bay and Nelson-Tasman caused their share of production to increase relative to the secondary regions. (Bagrie et al., 2015).

4.1.2 Reorganisation (α): mid 2000's to 2012

The reorganisation phase is a time when new groups appear and seize opportunities. Old connections are dismantled and new arrangements are made (Gunderson & Holling, 2002). The reorganisation phase is characterised by lower levels of connectedness, due to low internal control processes, but higher levels of potential due to the likelihood of developments and opportunities (Gunderson & Holling, 2002). Resilience is high during this phase because all options are available and novelty can thrive, enabling businesses to adapt to a wide variety of external factors (Gunderson & Holling, 2002).

Industry structure and power dynamics changed significantly during this period (Bagrie et al., 2015). The number of exporters in the market jumped from 1 to 90 between 2001 and 2005, and created opportunities for many early innovators and opportunists (Bagrie et al., 2015). However, for many growers, deregulation brought risk and uncertainty. Grower numbers peaked at 1700 in 1996, before dropping to 650 by 2005, (Bagrie et al., 2015). Deregulation ended ENZA's compulsory acquisition of apples, which meant growers had to adapt their operation and choose an exporter to survive in the new industry environment (Bagrie et al., 2015). Competition was intense among exporters to secure market supply in foreign and domestic markets. This caused exporters to undercut each other which reduced grower returns, increased financial pressure, and negatively impacted fruit quality (Dobbs & Rowling, 2006). According to Dobbs & Rowling's (2006) study, fruit quality lost consistency which had damaging effects on New Zealand's reputation as a premium apple producing nation.

Growers suffered from poor returns from 2004-2012 (Bagrie et al., 2015). This was due to poor apple prices, changing consumer and supplier demands, and eroding competitive advantages (Morris, 2006). However, deregulation was seen as the trigger that accelerated the decline through the mid 2000's (Bagrie et al., 2015).

Consolidation and corporatisation was a feature of the reorganisation phase and this drove major structural changes across the supply chain. Tables 4.1, 4.2, and 4.3, demonstrate market share changes for orchards, packhouses, and exporters.

Note: TCE is defined as 18kg of sale weight.

Table 4. 1 Orchard size share (Bagrie et al., 2015).

Year	0-5 hectares	5-15 hectares	15-30 hectares	30+ hectares
2007	14%	44%	23%	19%
2014	11%	43%	26%	21%

Table 4. 2 Pack house share (Bagrie et al., 2015).

Year	0-50,000 TCEs	50,000-150,000 TCEs	150,000- 500,000 TCEs	500,000+ TCEs
2006	4%	17%	42%	38%
2014	2%	8%	28%	62%

Table 4. 3 Export size share (Bagrie et al., 2015).

Year	0-50,000 TCEs	50,000-150,000 TCEs	150,000- 500,000 TCEs	500,000+ TCEs
2006	4%	9%	28%	59%
2015	4%	5%	14%	77%

The tables show orchards, packhouses, and exporters, operating at larger sizes (30+ ha and 500,000+ TCE's), increased market share over the time period presented. Pack houses, processing 500,000+ TCEs, increased their share from 38% in 2006 to 62% in 2014. Large exporters, exporting 500,000+ TCEs, increased from 59% to 77%. This indicates the shift towards corporates/larger vertically integrated organisations. Consolidation and corporatisation was occurring because larger organisations were able to generate greater and more consistent returns, reduce risk, and control supply. This was critical to:

- Optimise the consistency, quality, and timing of fruit (Bagrie et al., 2015; Participant 1, 2018).
- Build relationships and long-term contracts with large supermarket retailers (Norman, 2016).
- Control pipfruit volumes through the post-harvest facilities to maximise utilisation.

- Invest in R&D, technology, and proprietary rights to meet market demands, reduce production costs, and increase competitive advantage.
- Increase economies of scale to reduce costs and ensure financial viability (Norman, 2016; Participant 1, 2018).
- Generate higher wages and attract skilled workers (Norman, 2016; Participant 7, 2018).
- Reduced production risk with larger and more geographically diverse orchards (Norman, 2016).

Consolidation and corporatisation increased competition in the industry. Increased competition caused apples to commoditise, i.e. became distinguishable in terms of variety and brand (Norman, 2016). Prevar was established in 2004 to commercialise new varieties and sell growing rights which facilitated this process. Corporations were able to invest and obtain exclusive proprietary varieties and differentiate themselves to develop a competitive advantage (Bagrie et al., 2015).

Commoditisation was initially an issue for growers as it increased the number of competing apple varieties which decreased apple prices (Norman, 2016). However, eventually growers and marketers were able to specialize in club varieties and target niche markets (Norman, 2016).

New Zealand has a world renowned apple breeding programme, led by Plant and Food Research, that develops apple cultivars based on different cultivar criteria including consumer tastes, pest and disease resistance, productivity, and quality (Plant and Food Research, 2009).

The industry, once dominated by family-owned and operated orchards, reorganised into a corporate dominated industry (Participant 6, 2018; Participant 11, 2018). Many growers who stayed in the industry had to adapt and align themselves with larger corporates and become third party growers. The degree of orchard size consolidation (Table 4.1), compared to pack house and exporter consolidation (Tables 4.2, and 4.3) suggests many growers initially adapted to deregulation by becoming third-party growers. Third-party growers had greater access to technology, proprietary and intellectual property, management advice, and social networks, enabling them to be more competitive and survive in the new industry environment (Participant 1, 2018). However, this decreased flexibility and autonomy for growers, which reduces their ability to respond to changes (Participant 8, 2018).

By 2011, 10 years after deregulation, the industry was still “doing it tough” said Minister of Trade and Associate Minister of Foreign Affairs, Tim Groser (O’Sullivan, 2011). However statements from industry leaders including Grant Sinclair, director and former CEO of Scale Corporation, and Ian Palmer, former chairman of Pipfruit New Zealand, indicated there was greater optimism about the

future of the industry. Sinclair said he “was more certain than ever that growers could make money in the industry”. Markets in Australia and China were starting to open up, generating opportunities for growth (O'Sullivan, 2011), and increasing the potential in the industry.

5.1.3 Exploitation: 2012 - present

According to resilience theory, the exploitation phase will follow the reorganisation phase (Gunderson & Holling, 2002). The exploitation phase has large opportunity for growth as the capacity to deal with the new environment has been developed. Potential increases during this phase as capital accumulates. Likewise, connectedness increases as organisations and individuals develop the internal controls to manage the conditions and maintain stability (Gunderson & Holling, 2002).

Indeed, this is what we have seen in the apple industry. Since 2012, the industry has experienced strong growth, averaging 5% growth per year in export volumes (Stats NZ, 2018b). In the last three years, export revenues have exceeded \$700 million, reaching \$745 million in 2018, a record for the industry (Stats NZ, 2018b). The World Apple Review 2017 ranked New Zealand 1st out of 33 major apple producing countries, returning New Zealand to the position it was once in in 1995 (Ministry for Primary Industries, 2018).

All growers noted the prosperity and profitability of the industry. Hourly wages have increased, and growers are hoping this will attract more labour to the industry to support the labour shortages. One grower commented happily about paying income taxes again (Participant 3, 2018), while others commented on the relief to be out of the bad period, “It has come right now but it took a couple of years to pay off the debt.” (Participant 2, 2018), “the last 5 years have been very profitable for producing apples, before that it wasn’t so good, so there’s a lot more hype around the industry now, and we are seeing more external investors wanting to seize opportunities to make money” (Participant 7, 2018). Growers are benefiting financially from the growth and development, and are pleased about the direction the industry is heading in. A number of new orchards were developed in 2017 and 2018 and these trends are expected to continue (Aitken & Warrington, 2017; Mannering, 2017).

Nationally, the area of apple plantings has steadily increased, and is estimated at close to 10,000 ha, with Hawkes Bay accounting for 60% (Mannering, 2017; Stats NZ, 2018b). One participant put it, “this is the largest period of development I have ever seen” (Participant 1, 2018). Large development is occurring in the Hawke’s Bay which will likely increase the national share of production which will increase the concentration of apple production in the Hawke’s Bay.

Corporatisation has increased investment into R&D and caused significant technological gains (Participant 1, 2018). Technological improvements extend across the supply chain, including planting and pruning, new varieties, quality control, sorting, packing, and storage (Norman, 2016). Knowledge development increases adaptive capacity by increasing the ability to solve problems, plan effective adaptation responses (Seville, 2016; Whitney et al., 2017).

Furthermore, the New Zealand apple industry operates in a highly audited environment, described as an “audit culture” (Hunt et al., 2013). The audit culture has been driven by consumer demands, large retailers, and EurepGAP/GlobalGAP standards requiring high quality apple products. New Zealand apples can be traced from the orchard to the marketplace for quality assurance, and production processes require environmental, economic and social standards. The audit culture has created a point of difference from other apple industries around the world (Hunt et al., 2013). New Zealand has a good reputation for high quality apple production (Participant 1, 2018).

Comprehensive auditing provides knowledge across the supply chain and improves marketing and risk identification. This enhances the adaptive capacity by supporting learning and knowledge generation (Seville, 2016).

A wide range of apple varieties have been developed and commercialised. Many large companies specialise in club varieties that are bred for specific qualities and targeted foreign markets. The number of varieties in the market has increased diversity in the apple industry, a key indicator of resilience (Simonsen et al., 2015). A diverse range of apple varieties is more resilient than fewer apple varieties. This increases the capacity of the industry to respond to different environmental risks, such as climate change and pest and disease. It provides “insurance” so that the failure of any one apple crop will not have a damaging impact on the entire system. Corporatisation has increased diversity in the industry which has increased adaptive capacity (Biggs, Schlüter, & Schoon, 2015).

The apple industry also supplies to a diverse range of export markets. The United States is New Zealand’s largest export market, taking 14% of product by value, followed by United Kingdom (12%), Taiwan (11%), Thailand (11%), and China (8%) (Norman, 2016). This is a geographically and economically diverse range of export markets. The apple industry differs from other horticultural industries because export concentration is more evenly spread, and not concentrated into few markets (Norman, 2016). For example the blueberry industry exports 93% of national product to Australia, while the avocado industry exports 86% to Australia (Norman, 2016). In a highly interconnected and interdependent global market, organisations and industries are no longer isolated. Foreign countries, sectors, and individuals have the ability to disturb domestic operations through economic downturns, global political conflict, exchange rate fluctuations, regulatory

changes, or environmental disturbances (Fiksel, 2015). Foreign growing regions across the globe are vulnerable to the effects of climate change, which may impact the apple industry in New Zealand. This may create opportunities or disturbances depending on the impacts and regions affected. A diverse number of export markets increase resilience, diversifies risk, and buffers against shocks, therefore increasing the adaptive capacity of the apple industry.

A number of large corporations and vertically integrated companies operate in the Hawkes Bay including T&G Global, Mr Apple, Freshmax, Yummy Fruit Company, Sunfruit Orchards, Taylor Corporation, Mt Erin Group, and Bostock New Zealand. These organisations are responsible for the majority of NZ's production and exports. T&G Global produce approximately one third of New Zealand's apple crop (T&G Global, 2018). Mr Apple export approximately 25% of apple production (Scales Corporation, 2018) and Bostocks export approximately 85% of New Zealand's organic apple crop (Bostocks, 2019). Yummy Fruit Company, Sunfruit Orchards Limited, and Taylor Corporation operate significant planted areas of 700 Ha, 470 Ha and 300 Ha respectively (Participant 11, 2018; Yummy Fruit, 2018). Many of these large organisations are vertically integrated so they grow, pack, and export apples as a single company. These companies are self-organised and operate independently from each other. Mt Erin Group consists of several family-owned orchards, Bostock New Zealand is 100% owned by John Bostock, while T&G Global are a public company listed on the New Zealand stock exchange. Corporations are prevalent and strongly entrenched in the New Zealand apple industry, however there is large organisational diversity, particularly since many of these companies specialise in different club varieties and niche markets. This enables corporates to co-exist, run independent operations, and create redundancy and diversity in the apple industry enhancing adaptive capacity (Seville, 2016; Whitney et al., 2017).

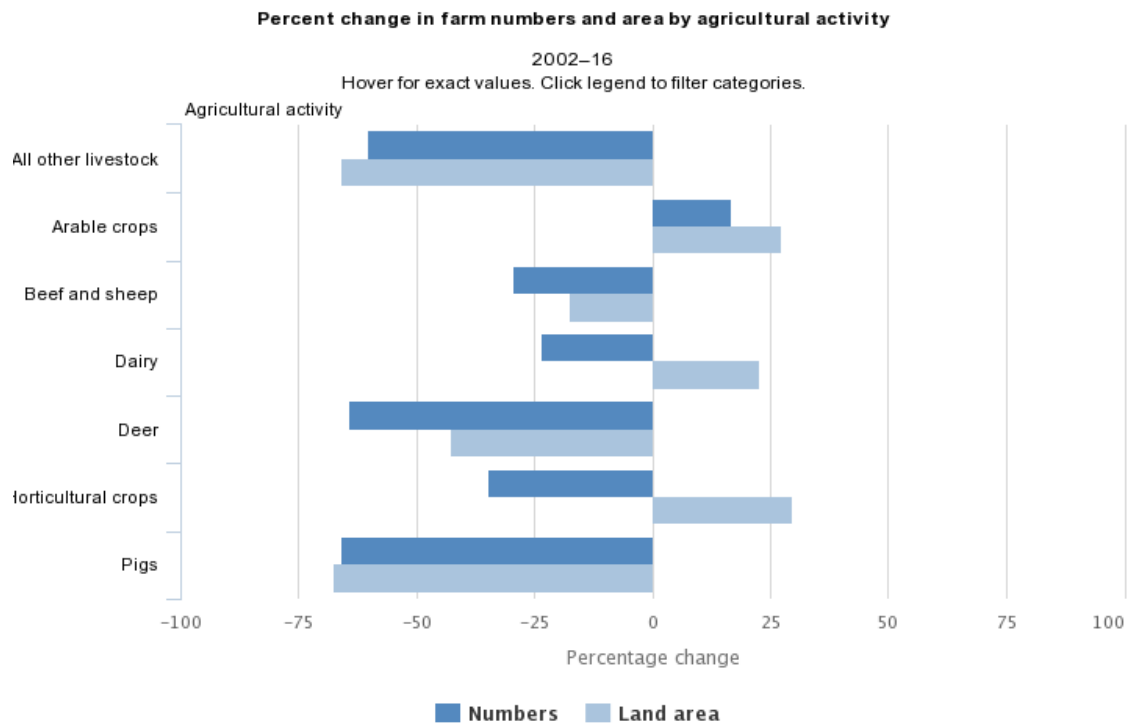
A mix of corporate owned and operated orchards and third party growers supply the large vertically integrated companies. Around 50% of T&G Global's apple production is produced by third party growers (Participant 1, 2018), and approximately 81% of Mr Apples apple is produced by third party growers (Scales Corporation, 2018). Other large companies operate differently, such as Yummy Fruit who produce 98% of their apples from Yummy Fruit owned orchards (Yummy Fruit, 2018).

A very small proportion of the growers interviewed run independent Free Alongside Shipping operations (FAS). These growers operate their business similar to the pre-deregulated, single desk days. They own the fruit and incur the risk across the supply chain, including transportation (Participant 6, 2018). Independent FAS growers, third party growers, and family-owned vertically integrated growers all expressed greater personal investment in their operations. Despite the

greater risks involved, they valued the flexibility, autonomy, and adaptability. “If we see a variety we want to plant, we are more adaptable, so can make that change.” (Participant 8, 2018).

Independent growers felt the prevalence of independent growers is decreasing in the industry, “We are kind of a dying breed”. “There’s no orchard owners. They’re all orchard managers. Everyone is leasing out”. (Participant 4, 2018; Participant 8, 2018). It is becoming increasingly difficult for small businesses and independent growers to operate in the market. Increased regulation, compliance and auditing requirements, and increased land value is making it harder for growers to stay competitive in the market (Participant 4, 2018; Participant 11, 2018). Participants commented on the challenges this has on their production. “Running a business is hard with increasing compliance, regulations, health and safety compliance and audits... We just want to grow apples... Corporates can specialise, whereas we spread ourselves thin”. Another grower commented “The old guys still owns the places, but don’t run them anymore. A guy in his 60s doesn’t want to deal with compliance, dealing with bad years, and regulations. So they lease it out which has decreased the number of individual orchard owner and operators.” Furthermore, land value is increasing due to the attractive returns being generated (Norman, 2016). This may create additional financial risk for some growers, increase debt, and increase the revenue requirements to service debt (Norman, 2016). This will reduce the resilience for many independent growers by reducing the range of conditions that they can operate at.

Figure 4.1 illustrates consolidation trends in the horticultural sector, showing changes in farm numbers and land area. This graph supports the claims made by growers about corporatisation and consolidation.



Source: Stats NZ

Figure 4. 1 Consolidation rates across primary industries (Stats NZ, 2018a).

Horticulture has experienced the greatest increase in land area while having a considerable decrease in industry participants across the 2002 – 2016 period. Although this data includes all horticulture products, pipfruit makes up a significant proportion of total horticultural production. Further full time employee (FTE) data suggest the apple industry has larger consolidation rates than other horticulture sector (Norman, 2016). Data shows the average apple producing business has 12.0 FTE's, compared to average horticultural business which has 3.6 FTE. The higher FTE in the apple industry indicates higher rates of consolidation (Norman, 2016). Furthermore, data on the number of “front doors” and “enterprises” operating in the apple industry indicate orchards are being sold to existing orchard owners, rather than being brought by new entrants (Norman, 2016).

In general, diversity and redundancy has increased following deregulation. Corporatisation has contributed to the development of club varieties and niche market specialisation, which maintains a diverse range of suppliers, cultivars, and export markets. The apple industry currently has diverse operations, with a combination of corporations, vertically integrated growers, and independent growers. The different entities have a variety of different business structures, production techniques, knowledge, preferences, and values. This improves the adaptive capacity of the apple industry by enabling different responses to disturbances and change (Biggs et al., 2015).

Furthermore, corporatisation and the development of large vertically integrated companies has increased supply chain management and coordination across supply chain components (Seville, 2016). This indicates an increase in connectedness, according to Gunderson & Holling's adaptive cycle model. Increased connectedness suggests the system has developed the necessary internal controls to respond to external stress. During times of crisis, high connectedness suggests the system has adaptive capacity to remain stable and resilient in the foreseeable future (Gunderson & Holling, 2002).

4.2 Panarchy

Panarchy refers to the nested set of interacting, semi-autonomous subsystems that make up social-ecological systems and is a component of the resilient thinking framework. In section 4.1, I described the structural changes that occurred in the industry as it went through deregulation. To understand the full effects of deregulation on adaptive capacity, a knowledge of the subsystem interactions and changes is required.

Subsystems are linked through their adaptive cycles. As they transition through their adaptive cycles, they can interact and affect the processes of other subsystems (Gunderson & Holling, 2002). A key feature of the panarchy concept is that subsystem interactions are asymmetrical, i.e. change can cascade up to larger scales and down to smaller scales (Gunderson & Holling, 2002). While larger, slower adaptive cycles generally control the faster, smaller adaptive cycles, it is not limited to this top down interaction. Smaller, faster adaptive cycles, that are sensitive to small disturbances, can change the variables controlling the processes of larger slower adaptive cycles (Gunderson & Holling, 2002).

The different subsystems that make up the apple industry social-ecological system have been categorised into three levels based on the speed, periodicity, and scale at which they operate (Figure 4.2). The first category is the 'fastest' level. This level generally operates at a local level like an orchard or plot system. The second category is the 'fast' level, which operate at a regional, industry, or community scale, and the third category is the 'slow' level whose systems operate at macroscale and affect global and national systems (Gunderson & Holling, 2002).

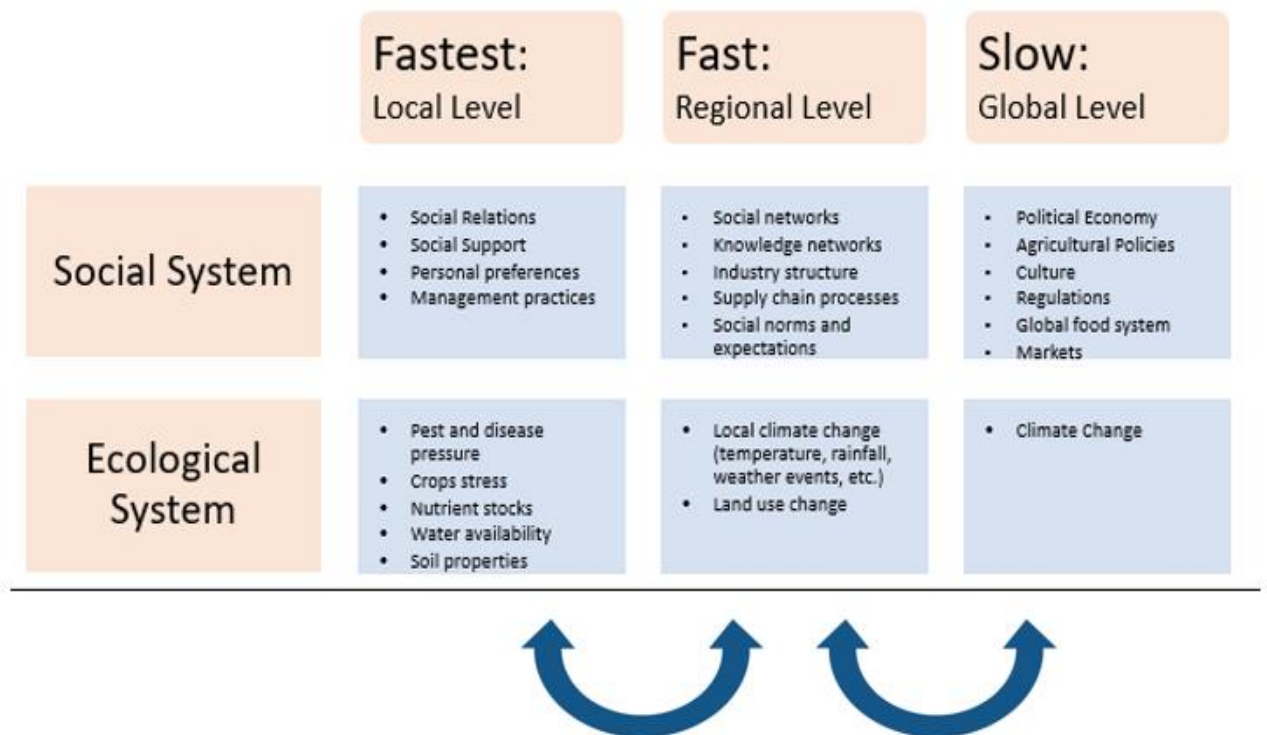


Figure 4. 2 Panarchy: The interactions, within and between, the different levels of the social and ecological domains, based on the speed, periodicity, and scale of which their variables operate.

What is not fully demonstrated in Figure 4.2 is that subsystem interactions can occur across and between the social and ecological systems. For example personal preferences and management practices, influence the crop health and performance of orchards at a local level. Figure 4.2.

illustrates the important role of scale in a social ecological system. Political change can affect subsystems operating at different scales and domains and influence lock-in effects, determine path dependency, and adaptive capacity (Wilson, 2014). For example, there have been profound changes in the structure, culture, and practices of the apple industry, a result of feedback effects and interactions between and across social, environmental, and economic scales (Participant 6, 2018).

Table 4.4 provides examples of change that occurred at the different levels due to deregulation. This table has been developed using interview data relating to social changes, categorised into the 'fastest', 'fast', and 'slow' levels to indicate the different scales social systems operate at (Lopez & Scott, 2000).

Table 4. 4 Examples of change to occur across and between different social systems.

Fastest	Fast	Slow
<ul style="list-style-type: none"> • Growers consult with a small collection trusted information sources. E.g. Consultant, trusted neighbour, or • Management practices are individualistic i.e. differ grower to grower. • Grower relations are competitive. Limited knowledge sharing, and social support. • Growers make a range of incremental adaptations in response to economic, climate, environmental, and regulatory changes. 	<ul style="list-style-type: none"> • Deregulation has increased corporatisation and consolidation. • The industry specialises in niche markets and club varieties. • Growers must comply with social, environmental etc. regulations and standard. • Networking groups have been developed in response to competitive culture (Young Fruit Growers Association). • Increased collaboration and joint ventures. • The knowledge network has increased. • Greater investment into R&D. • Apple varieties are developed from breeding programmes and commercialised 	<ul style="list-style-type: none"> • Neoliberal policies instigated deregulation. • Corporations dominate the industry in terms of production volume and exporting. • Consumers are demanding high quality assurances and 'green' production. • Audit culture has developed in the industry.

4.3 Thresholds and alternative regimes

Thresholds and alternative regimes represents the next key component to the resilience thinking framework (Folke et al., 2010; Nelson et al., 2007). This section investigates the system thresholds crossed and the new regimes that exist for growers operating in the apple industry. This section aims to link the structural changes identified in Section 4.1, and the hierarchical interactions described in Section 4.2, to describe the current context of the apple industry and its effect on adaptive capacity. Major changes identified following deregulation include changes in social capital, knowledge networks, environmental capital, and economic capital. These have important implications for grower's adaptive capacity in the apple industry (Whitney et al., 2017; Wilson, 2012).

4.3.1 Social Capital: Social networks, knowledge networks, and social support

Prior to deregulation apple growers operated in a cooperative, and did not compete directly with each other (Participant 6, 2018). Social networks were not defined by corporate affiliations, and growers did not choose exporters. As a result growers freely engaged with neighbours and the community, and the commercial element of apple producing did not interfere with grower relationships (Participant 3, 2018; Participant 6, 2018).

Deregulation increased the competition between industry participants and created a competitive culture. This changed the social system dynamics, reducing social capital and network connectivity between some growers and industry participants (Participant 3, 2018; Participant 7, 2018; Participant 10, 2018). "At the end of the day we are in competition with the neighbour", "there's no sharing of knowledge... the industry is competitive", "we do things our way, and we keep it in house", and "I once would have gone over to ask (neighbour) but now I wouldn't bother" (Participant 3, 2018; Participant 6, 2018; Participant 9, 2018; Participant 11, 2018). Competitiveness is more obvious among independent growers compared to orchard managers who manage corporate orchards (Participant 2, 2018; Participant 7, 2018).

Corporatisation has had different effects on social networks, including the bonding and bridging networks in the industry. Bonding networks, defined as the tight-knit cluster of relations (Bodin & Crona, 2009), changed following deregulation. Prior to deregulation, bonding networks did not depend on the exporter as all growers were part of a collective. Relationships developed through large scale ENZA field days (up to 300-400 growers), and other standard means such as neighbour connections or mutual interests and values (Participant 4, 2018; Participant 6, 2018). As corporates became dominant in the industry, they influenced bonding networks among apple participants, and became central nodes for many social networks. Independent growers now find they have closer connections with other growers from the same company (Participant 3, 2018; Participant 4, 2018;

Participant 11, 2018). Large companies have influenced bonding networks through orchard field days, grower meetings, and central communications which facilitate networking opportunities.

Bonding networks have been found to be beneficial for information sharing, knowledge generation, and social support (Bodin & Crona, 2009). Dowd et al. (2014), found bonding networks were important for adaptations because they provide information and social support resources. Bonding networks, facilitated or influenced through corporate connections, will enhance adaptive capacity by developing social capital. However, there is a risk bonding networks based around influential nodes, such as corporations, can cause the network to homogenise in terms of knowledge, technology, and management practices, and might create a barrier to transformational adaptations (Carolan, 2006; Dowd et al., 2014). Corporations were found to influence technology adoption by promoting technology at field days and suggesting best management practices to growers. Best management practices are not enforced by corporations but participants were found to adopt the recommended technologies, such as reflective mulch and planar technology (Participant 11, 2018). Technologies promoted by large companies are well researched, increase productivity, and improve management practices. However, there is a risk that corporations can reduce diversity across bonding networks by promoting the same knowledge, technology, and practices. Despite this suggestion, there was currently no evidence to suggest growers from the same bonding networks are converging towards a homogenous state.

Bridging networks have increased in the apple industry through networking initiatives domestically and internationally, exposing growers to more information and knowledge sources. It is common for growers to travel to different foreign and domestic growing regions to learn about new management practices and technologies. Dowd et al. (2014) found bridging networks are important for transformational adaptations because they provide diverse knowledge and perspectives that differ from the established norms. Individuals wanting to transform their land use or management practices often require information beyond their geographical, industry, or company boundaries (Dowd et al., 2014). It was evident growers and companies foster bridging networks to increase access to knowledge and increase adaptive capacity (Participant 1, 2018; Participant 2, 2018; Participant 8, 2018; Participant 11, 2018)

Several participants noted the competitive closed-door culture (Participant 3, 2018; Participant 6, 2018; Participant 7, 2018), however some participants, particularly orchard managers, thought there are signs the industry is shifting away from the competitive culture and developing a more social integrated culture (Participant 2, 2018; Participant 7, 2018). The following points outline why the competitive culture may be changing:

- Grower initiatives, such as the Young Fruit Growers Association, which have been set up to enhance networking, break down closed-door and competitive barriers, and establish a more socially integrated culture for the younger growers. “It is key for changing the culture, changing the mind-set, and building friendships. Learning how others do things and getting young people involved in the industry”. Other networking groups such as The Hawkes Bay Fruit Growers Association and the TANK group are other ways growers can get involved with the community and build larger networks. These groups share common goals and values, and enhance networking (both bonding and bridging), knowledge transfer, and social support (Participant 7, 2018).
- Increased social support to deal with labour shortages - a big issue in the industry. Several growers noted they have shared labour or reached out for additional labour during critical periods (Participant 7, 2018; Participant 11, 2018). This suggests the competitive culture is not limiting social support or solidarity when required. This is important because social support and solidarity demonstrate social capital, an indicator of adaptive capacity (Whitney et al., 2017).
- Niche market and club variety specialisation have meant large companies are differentiating themselves from each other and reducing direct competition. (Participant 1, 2018). A few participants believe this is slowly changing the social dynamics and culture of the industry. “We have found our little niche and tend to focus on and stick to that. It means you’re not stepping on other people’s toes as much and as a result people aren’t competing directly, so are more willing to share ideas.” (Participant 7, 2018).
- Increased inter-corporate collaborations, such as Fruitcraft, a company initiated by Bostocks, Mr Apple, and Freshmax to commercialise varieties (Participant 7, 2018). Furthermore, joint ventures are occurring to ensure critical supply of apples to new markets. Consumers require supply consistency to develop preferences, which is easier to achieve with multiple producers. One participant felt inter-corporate collaboration is having a positive impact on the industry culture by breaking down inter-corporate barriers and changing the perceptions of growers. “We are all Hawkes Bay growers... That’s what we are trying to teach the younger fellas, and get that mentality shift... Mr Apple and T & G don’t compete with each other, they compete with Chile, or South African growers who are converging on the same market as us” (Participant 7, 2018). This has the potential to improve grower relationships, and improve knowledge sharing and social capital (Whitney et al., 2017).

- Collaboration between growers and researchers, and growers and corporations was found to be common in Hawke's Bay. Plant and Food Research scientists work closely with growers to monitor technology adoption, and research trials. Likewise, growers collaborate closely with their corporation or pack house to share information and improve system performance (Participant 1, 2018). Cradock-Henry et al. (2018) and the Klein (2014) note the importance of collaboration between researchers and farmers to capitalise on farmer's local knowledge and enhance adaptive capacity.

Interestingly, growers who discussed these points and suggested competition was easing were all corporate employees or corporate orchard managers. The opinions of third party growers, independents, and family-owned vertically integrated growers were generally still highly competitive. These growers still felt the industry culture is limiting knowledge sharing and social support (Participant 9, 2018; Participant 11, 2018). This suggests independent growers feel greater pressure to remain competitive in the industry which may be associated to the greater personal investment required for operating independent orchards (Participant 6, 2018; Participant 9, 2018)

4.3.2 Knowledge Networks

Prior to deregulation, R&D was primarily directed and managed by industry groups such as Pipfruit Growers New Zealand Incorporated, and their subsidiary Pipfruit NZ (now New Zealand Apples and Pears), and public research organisations such as HortResearch and Crop and Food Research, who later merged to become Plant and Food Research. Figure 4.3 outlines the general structure.

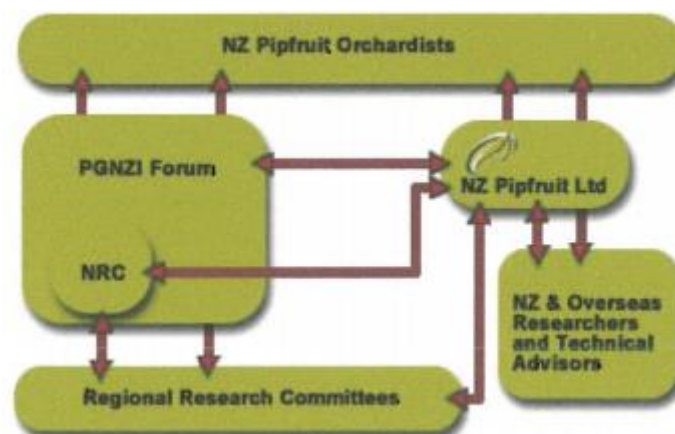


Figure 4. 3 Knowledge network (Gary, 2003).

Corporations have R&D programmes to develop the varieties they own the proprietary rights to. For example, T&G Global produce Envy and Jazz varieties, so have specialised R&D programmes to maximise the efficiency, productivity, and quality of these varieties. This knowledge is supplied to their orchards and third party growers exclusively. Corporates will work with their growers to enhance the innovation and technological development process (Participant 1, 2018). One grower

commented “corporations have a big pot of money they can use to pour into innovation and R&D. They seem to be doing that at the moment.” (Participant 4, 2018). Another commented “the big guys have their own innovation groups, which they keep in house.”

Smaller independent growers and vertically integrated growers, who do not have access to corporate R&D programmes or facilities, utilise other knowledge sources such as New Zealand Apple and Pears. New Zealand Apple and Pears is funded by a compulsory grower levy, so provides knowledge for all growers (Participant 1, 2018). New Zealand Apples and Pears collaborate with research institutions such as Plant & Food Research to develop knowledge.

Knowledge generation has increased due to corporatisation and private R&D programmes. This has increased the pool of knowledge and number of knowledge nodes in the network. The New Zealand apple industry has been ranked the most competitive industry in the world for the last four years, based on its productivity and technological innovations (Scoop Media, 2018). “Our world leading achievements reflect the ongoing investment and commitment to leading greater innovations, research and development, technologies, and environmental and social sustainability,” Alan Pollard, New Zealand Apples & Pears chief executive (Scoop Media, 2018). The World Apple Review (2018) noted New Zealand’s achievements are based on the number of new varieties that are routinely developed and commercialised. This highlights the significant role of innovation, and particularly Plant & Food Research’s breeding programme for creating new varieties.

The apple industry demonstrates a learning and innovation culture that is continuously developing and generating knowledge. Innovation and creativity is required to maintain a competitive advantage in New Zealand due to its relatively small size, export orientation and distance from major markets (Scoop Media, 2018). The industry demonstrates appropriate connectivity, through joint ventures and collaborations. The combination of an innovative culture, effective knowledge networks, and strong leadership are important elements that have increased the adaptive capacity of the apple industry (Seville, 2016). This ongoing learning process is necessary for adapting to change and improving performance during periods of stability and resilience during times of crisis (Seville, 2016).

Growers commented on the diverse growing operations and management styles in the Hawkes Bay (Participant 6, 2018). Growers indicated a major reason for the diverse practices is a high reliance on self-learning and discovery, learning-by-doing, and tacit knowledge development. “Everyone has their own way of doing things... it’s something that I discover”, “I will make changes based on what I observe”, “it’s personal preference and a process of self-discovery... my way is unique to my orchard” (Participant 2, 2018; Participant 3, 2018; Participant 8, 2018). Growers felt they had

significant autonomy over their orchard to implement adaptations and respond to the local environment (Participant 3, 2018). Adaptations occur at a local scale to respond to unique local climate and soil conditions.

The diversity of management practices in Hawkes Bay was said to be different from other foreign growing regions such as Italy, Spain and France. One grower noted “every orchard is the same (European orchards), absolutely identical.” European orchards were said to be more similar in terms of varieties grown, and orchard management. “They find something that works and roll it out across the entire industry” (Participant 6, 2018).

Competitiveness can be viewed as both positive and negative for enhancing adaptive capacity. Self-discovery and personal knowledge generation is important for optimizing management practices to the local environment and developing diversity across the region (Biggs et al., 2015). Participants indicated the competitive culture has contributed to this, however, participants also indicated competitiveness has reduced some amount of knowledge transfer between growers. Both diverse management practices, and knowledge sharing and social support are important for adaptive capacity because they drive innovation, novelty, and increases redundancy and diversity (Spector, Cradock-Henry, Beaven, & Orchiston, 2019). Key industry participants suggest networking groups and education might help increase social support and knowledge sharing, while maintaining competitiveness (Participant 7, 2018).

4.3.3 Environmental Capital

The current exploitation phase has caused significant expansion in the apple growing area.

Expansion is occurring on more marginal soil types that requires more laborious and intensive management (Participant 4, 2018). Soil type can limit the choice of rootstock and cultivars, and generally requires more drainage and irrigation infrastructure. High returns are driving land use expansion, which corporations are capitalising on as they have the necessary capital to invest in orchards and infrastructure. However expansion on marginal land that requires more inputs are more vulnerable to markets fluctuations due to tighter profit margins. Any changes in market condition will affect these orchards first.

Crop diversification is a way to increase resilience and adaptive capacity (Simonsen et al., 2015). It was common for growers to produce multiple apple cultivars, but less common to include other fruit crops such as kiwifruit and stone fruit. Roughly 50% of participants produced alternative crops to apples. Diverse cropping increases economic and ecological resilience as it increases the capacity to cope with crop failure security.

4.4 Adaptability and transformability

Adaptability and transformability is the final component of the resilience thinking framework.

Adaptability and transformability is the ability for a social-ecological system to utilise adaptive capacity and adjust to external disturbances to maintain resilience (Folke et al., 2010).

This chapter has so far focused on structural changes, and other social and environmental changes that have occurred in the industry. This section explores the perceptions to climate change, and how participants are responding to climate change in the Hawke's Bay. Climate change is a major risk that will require adaptation. It is important to understand how apple industry participants are respond to climate risk to gauge adaptive capacity to climate change.

4.4.1 Perceptions towards climate change and climate change adaptation

A range of perceptions were found regarding climate change. The majority of participants acknowledged climate change as a phenomenon except for two participants who were sceptical of its legitimacy. Those that acknowledged climate change, had a range of opinions regarding the extent and origins, i.e. whether it is naturally occurring and cyclical, or human induced.

Approximately one third of participants believed climate change is a cyclical phenomenon, consisting of natural seasonal fluctuations. They acknowledged bad seasons and good seasons but did not believe there have been any significant climate trends over their life time. Generally, this group were not concerned about the risks associated with climate change, nor concerned about the effects on apple production. They believed they will continue to deal with the good years and the bad years but manage the climate with appropriate management practices. "Sunburn, wind, we have seen nothing out of the ordinary. Just because you have a weather event one year, doesn't mean it will happen the next year" (Participant 4, 2018). This group acknowledged climatic risks, including sunburn, drought, and cyclones etc., but did not feel climate change will permanently change production systems or land use in Hawke's Bay.

Approximately 40% of participants believed climate change is occurring. This group discussed their observations, such as a warmer climate, and more extreme weather events. They also discussed data trends and what the science is suggesting (Participant 7, 2018). This group tended to talk about the effects on apples, including more sunburn, hail, irrigation demand, and pest and disease pressure. There was a mixed level of concern regarding the future effects of climate change on apple growing. One participant stated their concern about climate change having a negative impact on production in the Hawke's Bay (Participant 6, 2018), while the majority were less concerned about the future of apple production and thought the impacts would be manageable (Participant 5, 2018; Participant 10, 2018).

Fewer participants, approximately 20%, were unsure climate change is occurring. Generally, this group knew what the science is suggesting, but were unsure about how much to believe. Comments included, “It’s probably real, I just don’t know how much it will affect us” (Participant 11, 2018), “You have to be careful about who you start believing... it’s not a major concern for me.” (Participant 9, 2018). This group were not concerned about the future impacts of climate change on apple production in Hawkes Bay.

Lastly, approximately 10%, of participants did not believe climate change is occurring. This group did not trust media sources, and were unsure how accurate the science is. One participant commented “I don’t listen to what the news or media has to say about climate change... no one can tell me we will be getting 3 or 5 hail storms this season, no one actually knows...climate is not so much of an issue. I haven’t noticed any trends.”, and “I am not really a climate change believer”, “I’m pretty confident that things will stay much the same over the next 50 years.” This group were unconcerned about the future impacts of climate change on apple production in the Hawke’s Bay (Participant 8, 2018).

Growers unconcerned about the future impacts of climate change on apple production had confidence in technology, mitigation and their preparedness. Comments included: “spend the money now to mitigate the problem... We are ahead of the game in that respect, I will be prepared”, (Participant 3, 2018) “The natural process of innovation will keep us in front of the game. I mean, what more can you protect. You get frost, we got frost protection. Hail, we got hail protection. We’ve had hail insurance every year and haven’t had a claim the whole time.” (Participant 9, 2018) “We can cope with that, there aren’t extremes that can’t be managed. It’s about managing the weather with good crop and harvest management.” (Participant 10, 2018) and “There’s excessive sun, and excessive rain, however we can spray for that.” (Participant 5, 2018).

Growers felt significant progress has been made in recent years to adapt to climate threats and increase climate resilience. “In general, I think the industry is more aware of the climate and has come a long way from 10 years ago” (Participant 9, 2018), “We have moved out of being reactive, and are more proactive” (Participant 7, 2018).

Common adaptations include canopy strengthening, drain infrastructure upgrades to handle larger rainfalls and reduce boggy ground, overhead netting to reduce hail, sun, and pest damage. This study found growers were capable of investing in climate mitigating technologies and adaptations despite not perceiving climate change as a risk to future apple production. This suggests that the perceptions of future climate change risk do not necessarily reflect the ability to conduct climate risk assessment and adaptation implementation. Furthermore, technological implementation may be

sufficient to change the perceptions of future risk on apple production. However, studies have pointed out technologies can create a false sense of security, resulting in complacency to future risk (Rickards & Howden, 2012).

In general, growers implemented adaptations based on several social, environmental, and economic factors including investment, efficiencies, environmental, industry, market, and societal demands. Industry and market standards drive technological adaptations, particularly with regards to fruit quality, consistency, and tastes (Participant 7, 2018). Residue regulations, caused by societal and consumer demands, have caused growers to adjust spraying regimes, adopt IFP, and improve residue management (Participant 7, 2018). Furthermore, when introducing a new variety, growers must consider what the market and consumers demand. One grower noted “it depends less upon climate change but what will generate the biggest returns” (Participant 10, 2018).

Societal, and environmental requirements have increased the pressure on water supply and have caused regulations to change. Growers have adapted and will continue to adapt towards more efficient water use. This is driving technological adaptations such as moisture probes, and more efficient irrigation systems such as smaller irrigation blocks and precision irrigation (Participant 7, 2018).

Lastly, when implementing adaptations, growers must consider what will be financially viable to ensure profitability. “What provides the biggest bang for buck, and what will generate the biggest returns” (Participant 9, 2018). “We run a business, and need to have a profitable operation” (Participant 10, 2018). An early adopter of the future orchard system, said they could see the benefits of reduced labour costs (Participant 2, 2018). Likewise, growers investing in hail netting or planar canopies could see the co-benefits including increased productivity and reduced input costs. Growers noted they it was necessary to consider the co-benefits when implementing climate change adaptations.

Literature suggests a combination of several social, political, economic, and environmental factors influence the way people process information and develop perceptions (Whitmarsh, 2011). Growers received most of their information from consultants, field days, corporate communication, Apples and Pears New Zealand, and social networks. While there are multiple sources available to growers, participants noted they generally chose and relied on a few trusted sources.

Climate change was not a topic regularly discussed between growers or in their knowledge networks and social networks. The main source of direct climate change knowledge came from Hawkes Bay Regional council during monthly meetings (Participant 7, 2018). Yet, it was noted these meetings

were rarely attended until a major climate event had taken place. Knowledge enables individuals to reason future events, and use human agency, novelty and innovation. This will be important regarding climate change adaptation to use foresight and predict future risks and opportunities.

Growers perceived the main risks and opportunities regarding future production to be economic factors, such as market conditions, and macroeconomics variables such as exchange rates, trade relationships, and global disputes, followed by labour supply and environmental factors (water security, and climate pressures). Growers had confidence they were able to manage climate related pressures, through strategic and tactical adaptations. At this stage growers did not consider transformational adaptations, such as land use change, to be necessary. However some growers had diverse crops to diversify risk, and increase social-ecological resilience.

4.4.2 Exposure and Sensitivity

Growers are exposed and sensitive to a range of stimuli. It is important to understand these to understand what drives adaptations and transformations. Table 4.5 provides a summary of the impacts identified by growers. Potential impacts range across social, economic, political, and environmental factors. The main sources of climate change exposure and sensitivity are increased extreme weather events, water availability and security, and extreme hot weather.

Table 4. 5 Sources of exposure and potential impacts

Source of exposure	Potential impacts
Extreme rainfall	Boggy ground and row ruts, reduces row accessibility and can damage soil structure. Disease risk.
Drought	Water stress, reduced productivity and quality
High temperatures	Sunburn risk. Disease risk. Increases water demand for irrigation and heat mitigation (overhead spray). Increases biomass yield. Increases fruit quality. Reduces winter chilling and decreased budding. Reduces spring frost damage. Extreme high temperature can decrease yield and fruit quality
Hail	Fruit damage and decreased yield
Cyclones	Tree damage. Canopy structure and support infrastructure damage. Fruit damage.
Frosts	Decreased fruit quality and yield.
Labour shortage	Harvesting risks.
Market fluctuations	Decreases apples price and demand. Increases input price input supply.
Trade wars	Income. Market access.
Water Conservation Order	Decreases water allocation.
Regulatory requirements	Increases compliance and auditing.
Urban Sprawl	Decreases productive land use availability.
Land use change	Increases marginal land usage. Increases land price.
Financial changes	Interest rates increases. Land value increases. Exchange rates impact on returns and income.

The Ministry for Primary Industries (2012) predicted climate change to have an overall positive impact on fruit quality and yield, based on increased temperatures and carbon dioxide. Regardless, climate change exposes the industry and apple growers to range of potential negative impacts. The exposure and sensitivity to climate change impacts will determine adaptation planning and implementation, and hence adaptive capacity (Clothier et al., 2012). Adaptation implementation will vary between tactical and strategic adaptations (incremental adaptations) and transformational adaptations, depending on the magnitude and extent of the climate change impacts. However, growers are already making climate change adaptations as part of appropriate orchard management.

Water was a common issue for many growers. Too much rainfall and too little rainfall can have negative impacts on apple production and quality. Too much rainfall can create rutting and compaction issues. This affects human and tractor mobility between orchard rows, and damages soil structure if trafficking proceeds. Furthermore, too much rainfall can increase disease and pest risk. Too little can cause water stress and result in groundwater extraction bans. In the past, groundwater extraction bans have caused growers to truck water in for tree survival (Participant 2, 2018). Intensive horticulture and agriculture land use, urban population demands, and the effects of climate change such as droughts, will increase the pressure on groundwater and surface water resources. Growers are concerned how policy changes, such as the Water Conservation Order (WCO) will affect their water supply. The WCO has been proposed to increase the low flow on the Ngaruroro and Clive rivers catchments from 2,400 litre per second to 4,200 litres per second (Environmental Protection Authority, 2019). This is predicted to increase the average number of water bans from 10.3 days to 27.6 days per season according to a hydrology report submitted to the Environmental Protection Agency (Environmental Protection Authority, 2019). The WCO also seeks to protect the tributaries and hydraulically connected groundwater, which will affect the ability to build off-stem dams and storage infrastructure (Environmental Protection Authority, 2019). Growers believe this order would negatively impact their productivity. If the WCO passes, growers would be more exposed and sensitive to drought and periods of low-river flow. Adaptations will be required to increase water efficiencies and supply.

Climate change specific adaptations are hard to differentiate from market demand and profit driven adaptations. Many adaptations have co-benefits and are implemented with consideration of market, financial, or political/regulatory factors (Participant 7, 2018). The majority of growers considered these factors to have the greatest impact on orchard performance in the foreseeable future.

4.4.3 Adaptations and transformation

Growers use a number of adaptations to respond to climate risks and opportunities. Growers rarely implement adaptations in response to climate change alone (Participant 7, 2018; Participant 8, 2018; Participant 9, 2018). The most common adaptations applied by grower's involved tactical adaptations, i.e. daily adaptations in response to changes in conditions. Strategic adaptations were made in preparation for future climate events and conditions. Transformational adaptations were not commonly considered or implemented by growers, except for new cultivars or crops to diversify production (Participant 4, 2018).

Table 4. 6 Tactical, strategic, and transformation adaptations discussed by growers.

Type of Adaptation	Adaptation
Tactical	Cleaning field drains to increase drainage. Responding to climate conditions (i.e. turning on overhead irrigation, adjusting spray regimes) Soil moisture monitoring for irrigation efficiency. Using modelling and weather forecasts
Strategic	Strengthening crop canopies. Installing new drainage infrastructure Installing new irrigation systems Closer post spacing Filling ruts Future Orchard System (planar canopy) Stakeholder groups to inform policy makers (TANK group) Introduce new cultivars Overhead netting
Transformational	Land use change Diversify income Lease/sell orchard land

4.4.4 Institutional adaptations

The Ministry for Primary Industries has initiated several programmes to support R&D on climate change mitigation and adaptation research in the primary industries (Ministry for Primary Industries, 2019). Two main programmes that support climate change adaptation include the Sustainable Land Management and Climate Change (SLMACC), and Sustainable Food & Fibres Futures (SFFF). These are institutional adaptations that will have cross effects on the adaptation planning and implementation process.

Plant and Food Research (PFR) and Spain's Institute of Agrifood Research and Technology (IRTA), remain important in the innovation, R&D, and adaptation process. New cultivar, management practices and supply chain technology will be important in enhancing adaptive capacity. Researching programmes are considering the impacts of climate change and warmer futures in cultivar breeding criteria (Participant 1, 2018; Scoop Media, 2019). Likewise, corporations are planning for future conditions and investing in technology to prepare for industry changes (Participant 1, 2018).

4.5 Conclusion

The New Zealand apple industry demonstrated a similar adaptive cycle to the adaptive cycle theory outlined by Gunderson and Holling (2002). Prior to deregulation, the industry experienced a long period of growth during the exploitation phase. The system generated potential and connectedness and performed well in the global food market of the time. The industry then deregulated and reorganised. During the reorganisation phase, corporatisation and consolidation changed the structure of the industry. Corporates became dominate in the industry and the number of independent growers reduced. Market opportunities, competition and commercialisation supported the development of club varieties and companies to specialise in niche market opportunities. Diversity and redundancy increased as the industry reorganised in club varieties, export markets and business entities. In addition, the industry developed an audit culture in response to demands relating to food, quality, environment, and social standards which has increased supply chain monitoring and increased knowledge generation. This suggests adaptive capacity has increased in the apple industry following deregulation.

The structural changes caused by deregulation had many feedback effects on other social and ecological systems. A competitive culture developed, social networks broke down, and growers developed diverse management practices. Innovation increased due to investment in breeding programmes and private R&D programmes which has increased the number of apple cultivars and technology applied in the industry. Technologies have increased productivity, efficiency and fruit quality, and has improved the ability of apple industry participants to prepare for and mitigate

climate variability. Economic capital has enabled growers to invest in a range of proactive adaptations which have improved their capacity to adapt to climate events.

The majority of participants believe climate change will cause changes to orchard systems and will require adaptation planning and implementation. Growers consider the greatest climate risks to be extreme temperatures, extreme weather events, and water availability. However, growers are confident incremental adaptation will mitigate the effects of climate change in the foreseeable future. In general, growers considered economic and market factors to be greater risks to their current apple production operations.

I conclude deregulation has increased the adaptive capacity of the apple industry. Diversity and redundancy has increased, learning and knowledge generation has increased, and growers have the capacity to invest in technologies to mitigate the effects of climate change.

Chapter 5: Discussion and Conclusion

5.1 Caveats

The aim of this study was to investigate the adaptive capacity of the apple industry following deregulation. I used the lens of the resilience thinking framework as a method to frame the problem and characterise adaptive capacity. Results suggest the structural changes that occurred following deregulation have increased adaptive capacity in the apple industry, however there are four main caveats to this finding.

The first caveat is *the competitive culture that has eroded some element of social capital* in the apple industry. Research suggests social capital is an important component of adaptive capacity (W. N. Adger, 2003; Dowd et al., 2014; Seville, 2016). Following deregulation, the size and connectivity of social networks fell (Participant 9, 2018). This was due to corporatisation and increased market competition, innovation and technological competition, and labour competition (Participant 7, 2018). I found the erosion of social capital affected grower relationships and their ability to share knowledge. This has the potential to reduce learning and knowledge generation, which are key indicators of adaptive capacity (Whitney et al., 2017).

The second caveat relates to trends of *corporatisation and consolidation decreasing the number of independent growers in the market*. This trend can be expected to continue if benefits due to economies of scale, financial returns, and improved risk management exist. In addition, *land value* is increasing and there is downward pressure on apple prices due to technology advancements and low-cost foreign producers in China and Poland (Norman, 2016). These factors are *increasing the capital costs required to be competitive* in the market, *increasing debt* for some growers, and creating *tight profit margins*. This is increasing the financial pressure on independent growers, and making it harder for smaller growers and companies to operate in the industry. Continued consolidation and corporatisation may threaten the diversity of operations and industry participants which may have a negative effect on adaptive capacity.

Furthermore, *corporations now act as key nodes* in grower social networks. Research suggests key nodes can influence behaviours and perceptions, technology adoption, values, and management practices (Carolan, 2006). This can cause networks to homogenize (Burt, 2004), which reduces the variety of strategies and coping mechanism to respond to system shocks or crises. Corporate owned orchards are run by orchard managers who operate within a hierarchical decision-making framework, making corporate orchards more homogenous than their third-party counterparts. Further corporatisation and consolidation will increase the number of orchards operating under

corporate management. This will reduce orchard management diversity across Hawkes Bay, further reducing diversity and redundancy (Simonsen et al., 2015).

The third caveat is *reduced environmental capital caused by the expansion of apple production into marginal land zones*. Deregulation has increased corporatisation, technological development, and profitability which has contributed to apple area expansion. Several participants noted the expansion of apple production is occurring on less favourable land which is laborious and requires more inputs. “We are growing in areas that don’t have the lovely fluffy soils like Twyford... it requires more management... a few more inputs are needed. There’s no walking away and going on holiday” (Participant 7, 2018). *Urban sprawl* and *high demands for lifestyle blocks* are other factors decreasing the area of high quality, productive soils in Hawke’s Bay. These factors are reducing environmental capital and increasing the exposure and sensitivity to environmental, social, and economic changes (Whitney et al., 2017), decreasing adaptive capacity to the apple industry (Simonsen et al., 2015).

The final caveat relates to *growers’ perceptions on the future impacts of climate change*. This qualitative study, although involving a small sample size, found growers did not feel climate change would pose significant risks to apple production systems, or affect Hawke’s Bay’s position as a leading apple producing region. This may foster a level of complacency within the apple industry (Niles & Mueller, 2016). Research suggests perceptions on climate change can influence adaptive capacity (Arbuckle et al., 2015; Dang et al., 2019; Niles & Mueller, 2016). As a result, the perceptions demonstrated by apple producing participants may affect their ability to capitalise on future opportunities or comprehensively mitigate potential risks. However, growers were confident in the technology available to mitigate climate change risks and demonstrated high adaptive capacity through incremental adaptation implementation. This may be sufficient to buy growers time before more significant changes are required (Engle, 2011; Lawrence et al., 2018). This finding may not be a causal link to deregulation, however it is a significant finding that is highly relevant to adaptive capacity.

Further caveat’s that may reduce adaptive capacity which are not directly related to changes caused by deregulation include:

- Labour shortages in the Hawke’s Bay industry is a risk and has a negative effect on adaptive capacity.
- The Water Conservation Order may reduce water availability during low flow periods and limit the ability for growers to construct water storage infrastructure. This will increase pressures for growers and reduce adaptive capacity.

- Further regulations and compliance requirements that increase costs for growers will increase the pressure on growers.

5.2 Research gaps, strengths, and weaknesses

My research attempts to fill an existing gap in the literature assessing adaptive capacity through a resilience thinking lens. This presented an opportunity to apply the resilience thinking framework to a case study involving the Hawke's Bay apple industry.

The resilience thinking framework provided a novel approach to understand the system interactions, feedback effect, and cross-scales processes that affect adaptive capacity (Nelson et al., 2007). This was important because adaptive capacity requires a holistic approach that considers the context, path-dependencies, and system processes (Dang et al., 2019). *The adaptive cycle, hierarchies, thresholds and alternative regimes, and adaptability and transformability* were the key components of the resilience thinking framework used to frame my qualitative research findings.

The adaptive cycle was used to determine the structural changes that occurred following deregulation and create a detailed narrative of change. This was important because the industry structure represented a key variable that is influential in many social, cultural, and institutional processes. It was found that deregulation changed the stock of social capital, economic capital, environmental capital, and human capital. This had important implications on how industry participants mobilized resources, interacted with each other, generated knowledge, and managed their orchards, all important factors affecting adaptive capacity (Nelson et al., 2007; Whitney et al., 2017).

This analysis suggests the New Zealand apple industry is currently in the exploitation phase of the adaptive cycle. This is represented by high potential, connectedness, and resilience, and suggests the apple industry has a high capacity to adapt. In this case study, qualitative data from interviews and quantitative data from other literature provided several indicators which supported the adaptive cycle theory.

Assessing *hierarchies*, and *thresholds and alternative regimes* provided a framework to understand the different interactions and feedbacks across and between social and ecological system. This helped to consider the multiple factors that might characterise adaptive capacity.

Adaptability and transformability was the last resilience thinking framework component. While it was useful to examine apple growers' perceptions, exposures and sensitivities, and adaptations and transformations, I was not able to determine causal links between deregulation and the adaptability

and transformability of the industry. However, this section supplied useful information that affects adaptive capacity and the actions being taken to increase adaptive capacity.

Within the aim and scope of my research, the resilience thinking framework enabled me to assess adaptive capacity following deregulation and conclude the changes caused by deregulation have increased adaptive capacity.

I believe my research filled a research gap however, there are several weaknesses regarding the practical application of the resilience thinking framework. Applying empirical research to the resilience thinking framework was difficult to do. The resilience thinking framework is a loose and abstract framework which requires significant interpretation. Firstly, there are no clear boundaries to determine system processes or characterise the different phases of the adaptive cycle. The adaptive cycle is a generalised theory so cannot accurately define social thresholds, or anticipate social transitions and human agency (Sinclair, Rawluk, Kumar, & Curtis, 2017). Furthermore, it does not provide any clear indicators or measurements to identify changes to the independent and dependent variables.

Holling & Gunderson's (2002) adaptive cycle suggests systems become over-connected and rigid during the conservation phase before eventually releasing (collapsing). However, during the conservation phase, described in Section 3.4, the NZAPMB was able to respond to consumer and supermarket demands for high quality fruit standards. The NZAPMB rolled out the Integrated Fruit Production (IFP) system, while being in the conservation phase which is characterised with low adaptive capacity. The successful rollout demonstrated high adaptive capacity and highlights a major limitation with the adaptive cycle theory. A generalised model should not be used in an empirical study to indicate the dependent variable – adaptive capacity. The adaptive cycle is limited to being a metaphor to describe system tendencies as they move through periods of stability and rapid change. The adaptive cycle metaphor is a cycle with various degrees of predictability (Gunderson & Holling, 2002), which requires a large amount of interpretation and cannot be accurately applied. The main interpretations were based on how the adaptive cycle affects the adaptive capacity indicators, such as redundancy and diversity, economic capital, social capital, environmental capital, learning and knowledge development, and feedbacks. Adaptive capacity indicators were necessary to apply with the resilience thinking framework to assess the relative changes in adaptive capacity. However, the framework provides no means to summate the different indicators. The resilience thinking framework is a thinking framework that is more appropriately used as a theoretically thinking framework to consider adaptive change.

As others have found, the framework is only a guide to understand the effects of system change on resilience and adaptive capacity. This created confusion when trying to determine the effects of system threshold and cross-scalar processes on adaptive capacity (Sinclair et al., 2014). In this case study, several thresholds were crossed at both a grower and industry level, which in my opinion had an overall positive effect on adaptive capacity. For growers, increased income, technological availability, and knowledge all increased adaptive capacity. At an industry level, the development of the audit culture, competitive culture, innovative culture, and overall increased diversity increased adaptive capacity. These thresholds were identifiable in hindsight because I was able to determine the positive factors that have contributed to the current positive position apple industry participants are in. Given the industry has not had a recent collapse and is performing well, it is hard to determine the stimuli that are pushing the system towards critical thresholds that would lower system resilience or move the system to a less desirable state. Adaptive capacity is only assessable in hindsight because it is a latent property, therefore it is only until hindsight that the true drivers of adaptive capacity become apparent (Engle, 2011). Furthermore, adaptive capacity is not confined to individual scales. Multiple systems operating at different scales contribute to resilience and adaptive capacity. This study attempted to consider both the local context (the grower), and the regional context (the industry), on adaptive capacity. Adaptive capacity is generated across a variety of scales, system components, and supply chain processes. "Large-scale decisions affect small-scale systems, and small-scale adaptive characteristics add up to region-wide norms (Klein, 2014). It is very difficult to characterise adaptive capacity across scales and understand the full effects of cross-scale processes on aggregated adaptive capacity. Furthermore, this study characterised adaptive capacity which means the weight and the scale of the adaptive capacity indicators could not be taken into account. Nor did this study compare adaptive capacity to another industry to enable a relative assessment.

The complexity of climate change and range of spatial and temporal effects make it difficult to determine adaptive capacity over a range of possible events and risks. Addressing adaptive capacity to climate change requires analyses on the different climate change hazards across a range of temporal and spatial scales. The extent and magnitude of climate change risks will require different levels of adaptive capacity. To understand adaptive capacity to specific risks a vulnerability assessment is required. However, there are numerous challenges assessing adaptive capacity through a vulnerability lens because it does not take into account the context of the system and does not account for more than one threat.

5.3 Conclusion

Deregulation caused a significant transformation in the apple industry. The industry reorganised causing many structural changes, including supply chain processes, social networks, knowledge networks, and institutional frameworks. Further social, cultural, economic, cultural, and environmental changes occurred. These had notable effects on the competitive culture, the individualist working practices, and the social relationships in the industry.

The resilience thinking framework provided a lens to consider the interactions, processes, and feedback effects from deregulation. This resilience thinking approach was particularly useful for considering the apple industry's adaptive cycle and determining both the broader and local context of change.

Although this study demonstrates the difficulties of applying the resilience thinking framework in a practical application, it does highlight the value of using resilience thinking to imagine the future and think about system feedback effects and cross-scale system interactions. The theory may be useful for apple industry participants and decision-makers to incorporate into their thinking. This may draw attention to the slow changing variables such as climate change or political-economic change that might require transformational adaptations, or provide a framework to consider wider feedback effects, externalities, and maladaptations (Sinclair et al., 2014).

Key findings from this study also suggest industry leaders should take a more proactive approach towards climate change information dissemination. Hawke's Bay Regional Council was identified as a main source of climate change information. To ensure all apple industry participants are adequately prepared, climate change information should be discussed more comprehensively with apple growers. This will involve action from key nodes such as corporations and consultants to discuss the potential impacts, risks, and opportunities. This will put the apple industry in a good position to move forward, and manifest accurate perceptions to make informed adaptation decisions.

This research highlights potential consequences from an over-connected and rigid system. Moving forward, the apple industry should encourage diversity and redundancy, emphasise learning and knowledge development, and ensure apple participants are capable of self-organisation. Protecting the capacity for independent growers to operate in the market will be important to ensure these factors are maintained.

Future research on adaptive capacity should not take a resilience thinking approach. It should use clearly defined adaptive capacity indicators on a clearly defined population. The adaptive capacity

indicators should be assessed based on their relative contribution to higher or lower adaptive capacity. GIS mapping could be used to illustrate adaptive capacity over the apple producing regions of New Zealand, based on the adaptive capacity indicators. This would advance our understanding of the spatial distribution of adaptive capacity. It would also provide a more empirical indication of vulnerable apple producers or vulnerable apple growing regions to different climate, market, economic, social, or environmental variables.

Appendix: Method

Introduction

The aim and scope of this thesis was determined after attending two community workshops in the Wairoa and Hasting Districts, Hawke's Bay. The workshops were held as focus groups to gather data for a research project, hosted by researchers from Manaaki Whenua Landcare Research, NIWA, and Plant and Food Research. The workshop aimed to develop a pathway planning model to assist agriculturalists decision-making in response to climate change over different temporal scales.

Discussions from the focus groups identified several limitations and barriers regarding climate change adaptation in the Hawke's Bay (transport, people, skills, land use, resources, policy and knowledge). It was also identified climate change adaptation requires social organisation, social learning, and adaptive capacity. Furthermore, education, diversifying production, R&D, developing support services, and effective planning frameworks were all required to ensure effective adaptation.

The focus groups generated an outline of the major climate change opportunities, limits and barriers, however a gap in the research existed that addressed the commonalities, interconnections and interdependence between the factors that affect climate change adaptation. A holistic study that employed a system thinking approach was required to understand the context of the system and the position of the adaptor within the Hawke's Bay context. The apple industry was chosen as it is a major primary industry that is worth \$691 million in exports, with 60% production occurring in the Hawke's Bay.

Darnhofer (2010) used resilience thinking to assess farm sustainability in New Zealand, however it was a broad-brush study that did not generate a detailed case study. This thesis intended to generate a detailed case study to uncover key system characteristics that determine the context of the Hawke's Bay apple industry and the factors that affect adaptive capacity.

The resilience thinking framework provides a novel approach to assess adaptive capacity by considering the adaptive nature of social-ecological systems. Sinclair et al. (2014) used a resilience thinking framework that was adapted from the Folke (2006), and Walker & Salt (2006), to consider six concepts: (1) nonlinearity, alternate regimes, and thresholds; (2) the adaptive cycle; (3) panarchy; (4) adaptability; (5) transformability; and (6) general and specified resilience.

I used an adapted resilience thinking framework outlined by Walker & Salt (2006) and Sinclair et al. (2014) which considered the following four concepts:

- (1) The Adaptive Cycle
- (2) Hierarchies
- (3) Thresholds and Alternative Regimes
- (4) Adaptability and Transformability

The four concepts are discussed in detail in Chapter Two. They represent the key elements of the resilience thinking concept (Gunderson & Holling 2002)

Qualitative Research

A case study approach was used to develop an in-depth analysis of the apple industry set in the Hawke's Bay. I took a qualitative research approach to collect data to generate a narrative of the industry dynamics and understand the social, cultural, and economic aspects of apple production in the Hawke's Bay.

Previous studies on climate change adaptation in New Zealand's agricultural industries have used semi-structured interviews to generate information on climate issues, risks, opportunities, sources of exposure for growers, and climate change perceptions (Cradock-Henry & Fountain, 2019).

I took a similar approach and used semi-structured interviews as the primary approach to data collection. Semi-structured interviews allowed me to follow an interview script but be flexible to capture points that were relevant to the grower. Interviews were conducted in a conversation style, enabling me to explore each participant's personal context and capture social and cultural characteristics of the industry that were important to the individual.

The case study research approach used multiple data sources including interviews, observations, literature, industry reports, and media sources. This allowed me to capture a fair representation of the apple industry in Hawke's Bay and generate a full narrative of change that has occurred.

Data Collection

Prior to data collection, I made several phone calls and emails to develop some initial contacts in the Hawke's Bay region. I utilised contacts from Plant & Food Research and other personal connections to initiate snowball sampling and networking.

Interviews were conducted at the respondent's home and ranged from 30min to 1 hour. Upon arrival at a participant's house, I engaged in informal discussion to develop a relationship and would require a signed consent form. I used a voice recorder to record interviews which enabled me to focus on the discussion and review interviews at a later date.

The data collection period occurred over the August and September 2018 period. This was a convenient time for growers because it was during a quieter growing period. During the data

collection period, I based myself near Hastings, Hawkes Bay, to be close to apple producers. Participants were contacted via email first to outline the project, then by phone call prior to interviews to arrange a time and location.

In total 16 participants were interviewed, including 1 horticultural consultant, 1 corporate manager, 3 stakeholders, and 11 apple growers.

The interview consisted six question groups:

1. Farm History and farmer characteristics
2. Current issues in the industry
3. Current and Future climate challenges and opportunities
4. Perceptions of Climate Change
5. Adaptations
6. Industry dynamics

Data Analysis

Interviews were partially transcribed to obtain key quotes and paraphrased to obtain key ideas and themes. I made notes of key themes and quotes then coded data into categories and themes using Nvivo9.

Nvivo9 is a qualitative research software to analyse data. Data was coded for each participant and data source under the six interview question groups and the four resilient thinking framework concepts. This enabled data to be analysed for each participant, and interpret the data within the resilience thinking framework. Chapter Four presented the data and applied it in resilience thinking framework format.

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